AN ASSESSMENT OF DUST EXPOSURE LEVELS AND FACTORS ASSOCIATED WITH THE OCCURRENCE OF RESPIRATORY SYMPTOMS AMONG WORKERS IN THE ROAD CONSTRUCTION INDUSTRY IN LUSAKA, ZAMBIA

BY

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A dissertation submitted in partial fulfilment of the requirement for the degree of master of Public Health (Environmental Health).

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DECLARATION

I Nsunge Nsofwa declare that this dissertation represents my own work and that all the sources I have quoted have been indicated and acknowledged by means of complete references. I further declare that this dissertation has not previously been submitted for Degree, Diploma or other qualifications at this or other Universities. It has been prepared in accordance to the guidelines for Master of Public Health dissertation of the University of Zambia.

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CERTIFICATE OF APPROVAL

The University of Zambia has approved this research dissertation by **Nsunge Nsofwa** as a partial fulfilment of the award of Master Degree in Public Health (MPH)

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ABSTRACT

Research into dust exposure in the road construction industry and the prevalence of respiratory symptoms in Zambia has not been extensively conducted despite the respiratory symptoms forming the primary burden of occupational illnesses in Zambia. The absence of literature in this industry on occupational respiratory health symptoms and database for these workers formed the rationale for this present study.

This study assessed respirable dust exposure levels and factors associated with the occurrence of occupation respiratory health symptoms in Lusaka district (n=145). A cross sectional survey among road construction workers, conducted at three road construction sites; (Lusaka-Chisamba), (Lusaka- Kafue) and (Matero - Lilanda) roads. Personal dust samplers were used to assess the dust exposure levels and an adapted American thoracic health questionnaire was used to capture respiratory symptoms and factors associated with the occurrence of respiratory health symptoms. Spirometry test was also used to determine the lung function capacity of the road construction workers. Fisher's exact test was used to test for bivariate associations and logistic regression was used for crude and adjusted multivariate analysis between social demographic factors, job category, cumulative respirable dust, use of PPE, smoking and years exposed.

The prevalence of respiratory symptoms was nose irritation (59.3%), wheezing (45%) phlegm 29% and shortness of breath (39.3%).The mean respirable dust exposure level was 1.768mg-yr/m^3. Exposure to a cumulative respirable dust concentration of ≥1.768mg-yrs/m^3 was significantly associated with shortness of breath (OR 1.317; 95% CI; 0.125-0.802), (p-value (0.015). On factors associated with the occurrence of respiratory symptoms, education levels (tertiary education) was significantly associated with nose irritation (OR 0.257,95%CI; 0.076-0.862), (p-value 0.028) and job category (land clearing works) (OR 2.382; 95% CI;0.159-0.919), (P-value 0.032).The non-use of personal protective equipment by workers was significantly associated with respiratory symptom phlegm (OR 1.256, 95% CI;3.526-3.384), (p-value (0.007) and wheezing (OR 3.775,95% CI; 1.416-1.958), (p-value 0.008). The spirometry test results showed that 96% of the road construction workers had normal lung function, while only 4% of the workers had mildly to moderate lung impairment with the force expiratory volume ratio (FEV1) between 60% - 79%.

It is therefore, recommended that dust control measures be put in place at road construction sites in order to prevent dust exposure and the occurrence of respiratory symptoms and diseases.

Key words: Dust Exposure, Factors Associated, Respiratory Symptoms, Prevalence and Use of PPE

DEDICATION

I dedicate this thesis to my parents Joshua and Winnie Nsofwa who have always been my nearest and have been so close to me. It is their unconditional love that motivates me to set higher targets. I also dedicate this study to my Husband, Kanyanta Chewe for his moral and spiritual support and my beautiful children Chilangwa and Kanyanta. Thank you for being so patient with me and encouraging me to work hard. Mom loves you endlessly.

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DEFINITION OF TERMS

Associated factors

These are conditions which contribute to a worker having respiratory symptoms. These include: age, years of service, job category, smoking and alcohol intake.

Spirometry

The measurement of how quickly air can be expelled from the Lungs.

Forced Expiratory Volume in 1 second

The volume of air that the patient is able to exhale in the first second of forced expiration.

Forced Vital Capacity

The total volume of air that the Person can forcibly exhale in one breathe.

Lung Function

Refers to how well Lungs put oxygen into and removes Carbon dioxide from the blood or an FEV1/FVC ratio of greater than 70% (the ratio of forced expiratory volume in one second to forced vital capacity that is greater than 70%).

Lung Function Impairment

An FEV1/FVC ratio of less than 70% (the ratio of forced expiratory volume in one second to forced vital capacity that is less than 70%) or the distortion or weakening of the Lungs ability to put oxygen into and remove carbon dioxide from the blood.

Personal Protective Equipment

This is the protective clothing worn to prevent dust exposure. This includes: helmets, goggles, or other garment designed to protect the person's body from injury by blunt impacts, electrical hazards, heat, chemicals, and infection, for job-related occupational safety and health purposes.

Respirable dust

Mass fraction dust particles that penetrate to the unciliated airways of the lungs and the alveolar region.

Road Dust

Is fine dry powder consisting of tiny particles of the earth or waste matter lying on the ground on surfaces or carried in the air.

Occupational Respiratory Symptom

Is any symptom arising out of or in the course of employment? In this study this refers to wheezing, phlegm, nose irritation and shortness of breath.

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
COBD	Chronic Obstructive Pulmonary Disease
DALY	Disability Adjusted Life Years
ILO	International Labour Organization
ISO	International Standards Organization
MLSS	Ministry of Labour and Social Security
NIOSH	National Institute for Occupational Safety and Health
PPEs	Personal Protective Equipment's
PEL	Permissible Exposure Levels
PM 2.5	Particulate matter with an aerodynamic diameter of 2.5 Micro Meter (μm) or less
PM 10	Particulate matter with an aerodynamic diameter of 10 Micro Meter or less
TLV	Threshold Limit Values
TWA	Time Weighted Average
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background information

Zambia has launched the link Zambia 8000 road construction campaign, according to the Road Development Agency Corporate Magazine 17th edition (2014) report, an estimation of 20,000 workers have been employed to work in the road construction industry. These intensive activities have resulted in increasing quantities of contaminants into the urban environment. Consequently, a variety of environmental problems have cropped up and toxic metal pollution has become a major issue, especially in urban air (Bilos et al., 2001).

Road construction is one example of heavy constructions that may have a substantial temporary negative impact on local air quality. During heavy construction, dust emissions are released into the air by several activities, equipment movement on unpaved surfaces cut and fill operations, excavation activities, crushing, land clearing, wind erosion of soil exposed by construction activities. This source can have an impact on the quality of air alone which can impact the ones living in close proximity to the construction works and more especially the employees working in the road construction. It is particularly of worry if dust consists of elevated levels of metals (Tompkins, 2010).

Road construction is a lengthy process that can take more years depending on the length of the size of the road. It involves several construction crews and plant machinery. However, the processes that generate dust include: -

1. Clearing and excavation- removal of trees and shrubs, excavation vehicles also dig up and remove the rocks and stones from the future path way.
2. Mounting- the road takes shape as the diggers, excavations plant machinery and bull dozers mount dirt and soil. The surface is then levelled and smoothed by graders.
3. Fine grading- this requires construction workers to prepare the surface by levelling it. Fine grading requires manual labour and digging as well as grading plant machinery.

It is during these processes that workers can be exposed to a substantial amount of dust if the levels of dust exposure are not put under control, Road development Agency (RDA), 2015).

Dust concerning occupational health is the fraction of fine sized particles generated and is classified into three primary categories namely, respirable dust, inhalable dust and total dust. Respirable dust refers to the dust that has particle size smaller enough to penetrate the nose and upper respiratory system and deep into the lungs and is particularly of a health problem. This study focuses mainly on respirable dust because of its significant health concerns and impact on those exposed to it. Dust with aerodynamic diameter less than 10 µm and approximates to the fraction that penetrates to the gaseous exchange region of the lungs as outlined by the (National Institute of Occupational Safety and Health (NIOSH), 2012).

Respirable dust and its related health effects must be controlled by reducing employee exposure to the dust and this can be accomplished by three types of counter measures, namely prevention, control system and wet suppression of dust or isolation of workers. It is well believed that prevention is better than cure, and therefore it is important to reduce dust generation, emission, and dispersion, although complete prevention of dust is an impossible task. Therefore, the dust that cannot be prevented from the source must be reduced at all cost, (NIOSH, 2012).

1.2. Risk factors associated with dust on the respiratory function

Road dust is a complex mixture of particles and may contain various components like organics, heavy metals, and other inorganics, which can possibly get suspended due to movement of the earth working machines during construction works resulting in an important source of atmospheric air pollution. It is observed that dust remain suspended in air longer under certain meteorological conditions. In addition, road dust is an important environmental indicator of metal contamination from construction activities, and resuspension of contaminated soil (Bilos et al., 2001), (Bhanarkar et al., 2005), (Gupta et al., (2012).

Air pollutants can come from many sources and include both gaseous and particulate matter as cement dust. Particulate matter (PM) is the principal component of indoor and outdoor air pollution. Particulate matter is a complex, multi-pollutant mixture of solid and liquid particles suspended in gas. The primary exposure mechanism to particulate matter 10 and other particle sources is by inhalation. The lung interfaces with the external environment and is frequently exposed to air pollutants, such as particulate matter, it is prone to oxidant-mediated cellular damage, the adverse health effects of particulate pollutants may be explained by several mechanisms, including innate immunity, adaptive immunity, and the production of reactive oxygen species (Nel, et al., 2006).

Particles larger than 10 μm generally get caught in the nose and throat, and never enter the lungs after inhalation of particulate matter, phagocytic cells including neutrophils and macrophages are recruited to the foreign particle by cytokines and chemokines, and transported by the mucociliary escalator for removal. Systemic inflammation in the airways leads to deterioration of lung function and it possibly increases the risk of chronic pulmonary disease, cardiovascular disease and several neurological and skeletal defects. In addition, inflammation, a mechanism that lies behind several pulmonary and extra pulmonary diseases, can be induced by the oxidative stress following particulate exposure (Delfino, et al; 2005).

The studies on particle mass concentration (PM_{10} and $PM_{2.5}$) show that there is no lower limit for particle mass below which is no health danger. This is presented in the guidelines of the World Health Organization (WHO, 2005), for air quality which outlined a linear relationship between PM_{10} and $PM_{2.5}$ with various health indicators including mortality, hospital admissions, bronchodilators use, symptom aggravation, cough and peak expiratory flow for concentration levels from 0 to 200 μgs/m³.

Particulate matter may produce direct vascular injury by activating inflammatory and oxidative stress pathways leading to the release of fibrinogen, platelet activation factors, and endothelin's, all of which are potent vasoconstrictors (Brook, et al., 2004).

The National Institute of Health And Welfare outlined the health wise importance characteristics of Particulate Matter (PM). These characteristics are outlined below:

1.2.1. Coarse thoracic particles ($PM_{10-2.5}$, diameter 2.5- 10μm)

These comprise mainly of soil minerals, biological materials (pollen, plant debris,) and microbial material (bacterial, spores, endotoxins) poor water solubility. The particles are mainly deposited in the trachea and the larger bronchi and in most cases are quickly removed due to mucociliary clearance.

1.2.2. Fine Particles (PM2.5; diameter < 2.5 µm)

These comprise mainly of soot and organic combustion material, inorganic salts ($SO_4$2- NO_3, NH_4^+), transition metals (Fe, Cu, Ni, V and Zn) and carcinogenic metal compounds (As, Cd, Ni). These are mainly deposited in the small alveoli macrophages.

1.2.3. Ultrafine Particles (UFP; diameter < 0.1 µm)

These have small mass, soot and organic combustion material in vicinity to traffic, natural formation from vegetation – derived volatile organic compounds (VOC), and variable water solubility. These particles are deposited mainly to the alveoli and some penetrate to the blood circulating organs.

The dust contaminants occur in the gaseous form (gases and vapours) or as aerosols. Aerosols may exist in the form of airborne dust. In the occupational setting, dust exposures of all forms are important because they relate to a wide range of occupational respiratory illnesses. Airborne dusts are of particular concern because they are well known to be associated with classical widespread occupational lung illnesses such as the pneumoconiosis, chronic obstructive pulmonary disease (COPD), occupational asthma, emphysema, bronchitis and other respiratory symptoms.

1.3. Occupation Health and Safety in Zambia

Occupational health and well-being of working people are of utmost importance for overall socio-economic and sustainable development. However, the workplace can be a hazardous environment. Occupational health and safety hazards are common in many economic sectors and affect large numbers of workers (International Labour Organisation, (ILO), 2010).

The Joint ILO/WHO (1953) Committee broadly defined Occupational Health as “The promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of the workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological equipment and, to summarise: the adaptation of work to man and of each man to his/her job”.

Historically in Zambia there were only safety rules for the mines and other risky undertakings under the Factories Act Cap 441 of the laws of Zambia. It is now that health and safety issues of labourers cover a full spectrum of dangers arising from the modern industrial process. Nevertheless, the inability to implement occupational health and safety legislation combined with non- incorporation (domestication) of some of the ratified International Labour Organization conventions such as the safety and health into Zambia’s municipal law has left workers without legal remedies when their rights have been violated. The position of the informal sector is worse since the current labour legislation does not directly cover them. This suggests that the Laws on Occupation Health and Safety Standards in Zambia are not yet at par with the recommended requisite Standards (ILO, 2010).

Inadequate legislation can be said to be contributing to poor occupation health and safety standards. This is because even though the legal frame work exists, it does not adequately cover all. The workers who are most covered are those in the Mines and in Factories and places of which the Act does not expressly define covered by the Factories Act (Loewenson, 2000).

In addition, the problem of protective clothing is worsened by the fact that there is no mandatory legal requirement that the Zambian Bureau of Standards should approve the health and safety clothing use in Zambia and hence poor quality and ineffective clothing is being used. The situation has worsened by the silent suffering of workers who for fear of losing their jobs do not speak out on the unsafe conditions in which they work under, (MLSS, 2013).

In a report by Workers Compensation Control Board (WCCB, 2014), it was indicated that the current statistics showed that an average of 1200 accidents and illnesses are reported to the board annually for the purpose of settling compensation claims in respect of occupation accidents and illnesses.

However, in an effort to control respirable dust levels, the Occupation Health and Safety Act of the laws of Zambia has set a threshold limit value 1.74mg/m3 for respirable dust exposure.

1.4. Statement of the problem

The road construction industry with the link Zambia (8000) campaign in Zambia is poised for a huge growth in the coming years. However, it is well known that in developing countries like (Zambia) there is lack of operation research to address prevalent occupational conditions. In addition there are weak policies and insufficient trained staff to perform risk assessment and risk management. This makes it difficult to strengthen and promote strategies for risk assessment and risk management. Further there is also lack of dust exposure levels monitoring and surveillance of occupational illnesses and injuries as outlined by the International Labour Organisation (ILO, 2010).

Occupational exposures are amongst the leading causes of respiratory illnesses globally and are associated with respiratory symptoms in both formal and informal occupational settings in developed and developing countries, Schulger, et al., (2014). Studies in the developing world report a prevalence of respiratory symptoms ranging from 11.4% to 31.8%, (Chen, et al., 2006).

In Zambia about two thirds (69.7%) of workers potentially suffer from respiratory illnesses resulting from occupational exposures as reported by (Workers' Compensation Board (WCB), 2014). It is reported that approximately 30-50% of the workers report dust exposures and these individuals spend one-third of their adult life in such hazardous dust work environments and globally, 120 million occupational accidents with 200,000 fatalities are estimated to occur annually and some 68-157 million new cases of occupational illnesses caused by various exposures at work (ILO, 2010).

In a report by World Health Organization, (2015) it was stated that, only 5-10% of workers in developing countries and 20-50% of workers in industrialized countries (with few exceptions) have access to Occupational Health Services.

It is therefore necessary to study dust exposure levels and factors associated with the occurrence of respiratory symptoms and address the health risks associated with dust exposure in order to protect the road construction workers in Zambia from further dust exposure by providing recommendations on dust palliative measures.

1.5. Justification

Operational research in the road construction industry is totally lacking in Zambia. No study has conclusively proved the dust exposure levels and the prevalence of respiratory symptoms in the road construction industry, hence the need to gather epidemiological evidence on dust exposure levels and the occurrence of respiratory symptoms among the road construction workers.

There has been conflicting evidence in literature review on the occurrence of respiratory symptoms in workers in dusty industries like the road construction industry. Studies have attributed differences in the exposure levels of dust. On the other hand studies conducted have mainly focussed on methods of intervention for dust suppression and elimination. There is limited information on the dust exposure levels in the road construction industry and the factors associated with the occurrence of respiratory symptoms. However this study will help to measure the dust exposure levels and determine the prevalence of the respiratory symptoms.

Zambia Environmental Management Agency, (2014) alludes that data on dust generation and exposure in road construction industry in Zambia is insufficient for policy-makers to create dust exposure monitoring programs and intervention strategies. Therefore, this study is needed to identify levels of dust generation and exposure and the factors associated respiratory health outcomes in road construction industry in Zambia.

The study is instrumental in the health status evaluation of road construction workers as it provides the baseline for elaborative studies in future. Therefore, it is envisaged that this study will come up with information and results on dust exposure levels that are useful to different users, policy makers and occupational health and safety regulators in the road construction industry. The research will also provide information on the estimates of respiratory symptoms in the road construction industry and indications of the health gains that could be achieved by targeted action against specific risk factors.

1.6. Conceptual framework

Figure 1. Showing the conceptual framework on factors associated with the occurrence of respiratory symptoms

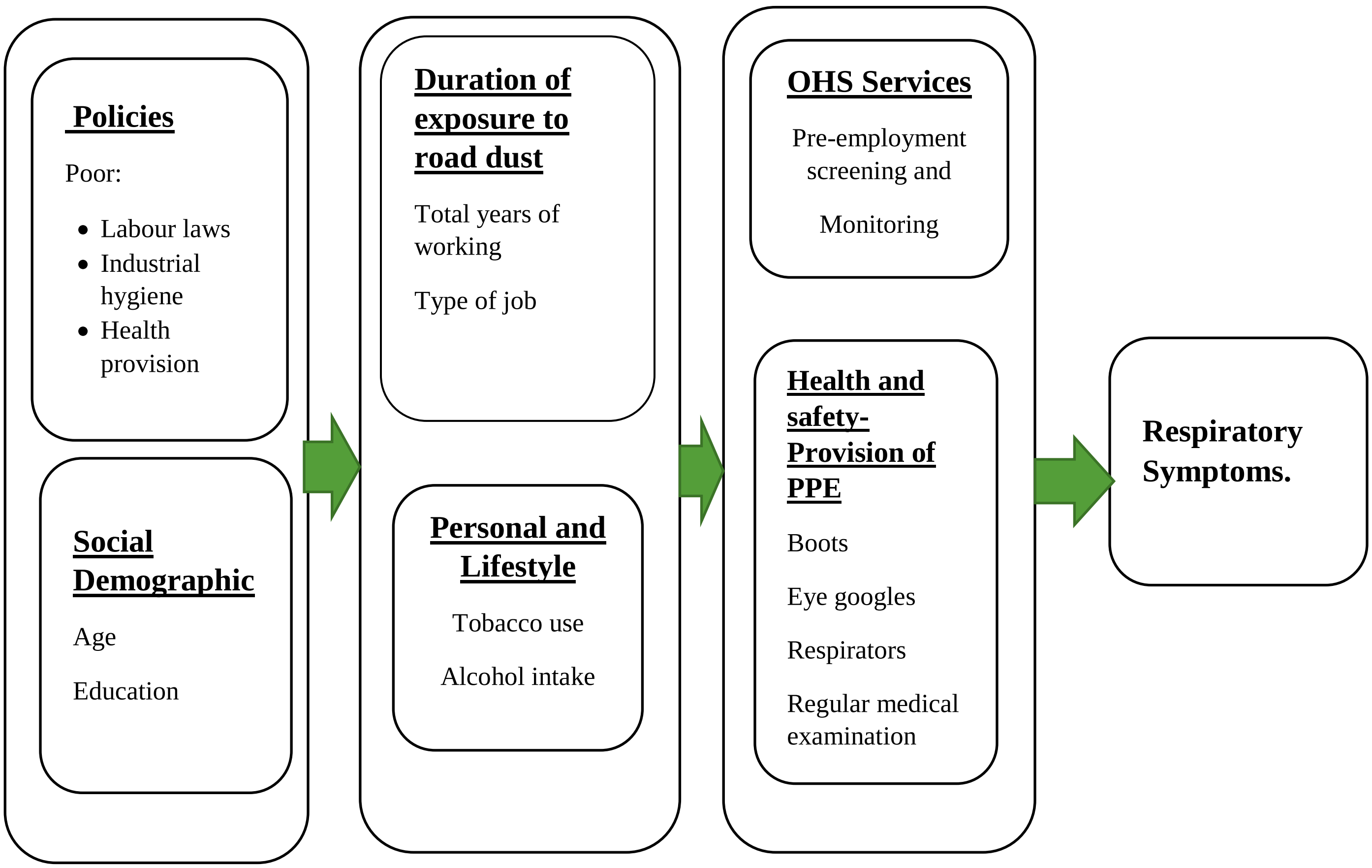

Figure 1. Shows the conceptual framework on the factors associated with the risk of respiratory symptoms. The figure conveys the broader contextual picture of the pathways to the occurrence of respiratory symptoms among the road construction workers. The various determinants that have appeared from the review of literature have been duly put in their places across the framework and then interlinked has shown in the framework. The exposure to dust being the primary interest of study has been highlighted and the outcome has also been highlighted as an increase in respiratory symptoms.

1. 7. Research Questions

1. What are the dust exposure levels among road construction workers in Lusaka district in Zambia?
2. What factors are associated with the occurrence of respiratory symptoms among road construction workers in Lusaka district in Zambia?
3. What is the prevalence of respiratory symptoms among the road construction workers in Lusaka district in Zambia?

1.8. Objectives

1.8.1. General objective

To assess dust exposure levels and factors associated with the occurrence of respiratory symptoms among road construction workers in Lusaka district in Zambia.

1.8.2. Specific objectives

1. To assess the dust exposure levels among road construction workers at workplace sites in Lusaka district in Zambia.

2. To determine the factors associated with the occurrence of the respiratory symptoms among the road construction workers in Lusaka district in Zambia.

3. To determine the prevalence of respiratory symptoms among the road construction workers in Lusaka district in Zambia.

4. To assess dust control measures used in the road construction industry in Lusaka district in Zambia.

CHAPTER TWO

LITERATURE REVIEW

2.1. Occupational disease burden: Global and Zambian context

Globally occupational risks are estimated to be the tenth leading cause of morbidity and mortality among the global risk factors. The cost of occupational disease burden is estimated to be 2-14 % of the gross national product for various countries. The work-related risks were estimated to cause 775,000 deaths globally in 2000, and of this the leading causes were unintentional injuries (41%) followed by Chronic Obstructive Pulmonary Disease (COPD) (40%), and cancer of the trachea, bronchus or lung (13%) being the major contributors of deaths. The occupational injuries caused 310, 000 deaths, then dust-related deaths were 243, 000 and the work related carcinogens 146,000 deaths according to (WHO, 2003).

The most recent estimates available from the International Labour Organisation (ILO, 2012) suggest that around 2.2 million people die due to work-related accidents or illnesses each year. Three hundred and fifty thousand of these deaths are due to accidents and the rest are due to occupational illnesses and diseases. On top of this, (ILO) estimates that there are 264 million non-fatal accidents each year that result in a 3 plus day absence from work, and 160 million people with work-related illnesses. ILO believes that the cost of work-related ill health and accidents costs the world 4% of the global GDP or $1.25 trillion US dollars.

2.2. Dust exposure

Though the benefits of paved roads are numerous, the investment in converting gravel road to pave brings about respiratory health effects to the road workers assigned to do the construction works and the communities nearby. Road dust is a hazardous substance, it is a respiratory sensitizer and is known to cause respiratory symptoms such as (Nose irritation, wheezing, shortness of breath, fever, stuffy nose, and skin itching/rash) and diseases like allergic rhinitis and occupational asthma among road construction workers. Asthma arising from workplace exposure is one of the commonest types of occupational asthma. Road dust is also an irritant and may give rise to short term respiratory, nasal and eye symptoms or it may provoke an asthmatic attack in individuals with pre-existing disease and also lead to chronic bronchitis (Chaldreen, 2012).

In addition, road workers have been reported to exhibit a variety of clinical manifestations including wheezing, febrile reactions, lung fibrosis, allergic alveolitis, impairment of lung function and chronic obstructive pulmonary disease.

The inhalation of road dust also causes severe health problems including pulmonary problems, while dust deposit causes skin and eye problems. The major health concern of dust exposure is inhalation of crystalline silica dust which lodges in human lungs thereby causing respiratory and pulmonary damage such as silicosis, which increases the risk for other lung diseases such as bronchitis, pneumonia, tuberculosis, and lung cancer. The deposition of the heavy metals during road constructions may sometimes also cause kidney, brain damage and lung cancer (Martin and Griswold, 2009). In addition, studies have shown that shortness of breath, chest pains, cough and wheezing may be an indicative of the onset of Silicosis.

Several Occupational Health Organizations have tried to evaluate the severity of health hazards like respirable dust in a workplace, for example, the American Conference of Governmental Industrial Hygienists, (2007) report adopted a number of standards to evaluate the severity of health hazards. One of the standards it looked into is the Threshold Limit Value (TLV), the Time Weighted Concentration to which nearly all workers may be exposed to 8 hours per day as total work shift over extended periods of time without adverse effects with the combination of the other established Regulations and Acts. It is believed that the respirable dust and its impact must be under good control under these regulations.

It is difficult to pinpoint health effects due to road dust emissions, as emissions are intermittent, they are highly seasonal and a low number of people are exposed. Moreover, Chaldreen, (2012) in her study points out that it is difficult to quantify the effects of individual chemical components, such as black carbon, metals, secondary sulphates and nitrates and organic components. She also stated that coarse particles may be as toxic as fine particles on short time scales, even though the biological mechanisms are different, and that long- term exposure effects can occur through the progression of underlying diseases, not just the exacerbation of short- term effects.

Many studies have little to say specifically about road dust as a source in itself. However, there is evidence of health risks due to toxic metals, which are contained in dust from road construction even though there are uncertainties over which components are the cause (crustal, anthropogenic or biological). In light of these uncertainties, Environmental Protection Agency, (2015) recommends that all particulate matter should be treated as if they have the same impact on public health, so that, for instance, the effect of the PM_{10} component of road construction dust is presumed to be the same as that of PM_{10} from other sources such as wood burner smoke or diesel particulate material. This is not because the effects are actually equal, but because the sources cannot be distinguished in the epidemiological data.

Various researches have shown that dust on site have adverse physiological and psychological effects on workers. It is called the slow killer because the effects start showing in the intermediate or advanced stages of illness. Workers exposed to road dust for a longer span have been known to have multiple health problems in the long run. Thus dust on site is a potential health hazard to the workers as well as the people surrounding the site (Lumens and Spee, 2001).

2.2.1. Dust composition from different sources

Figure 2. Showing the composition of dust from different sources

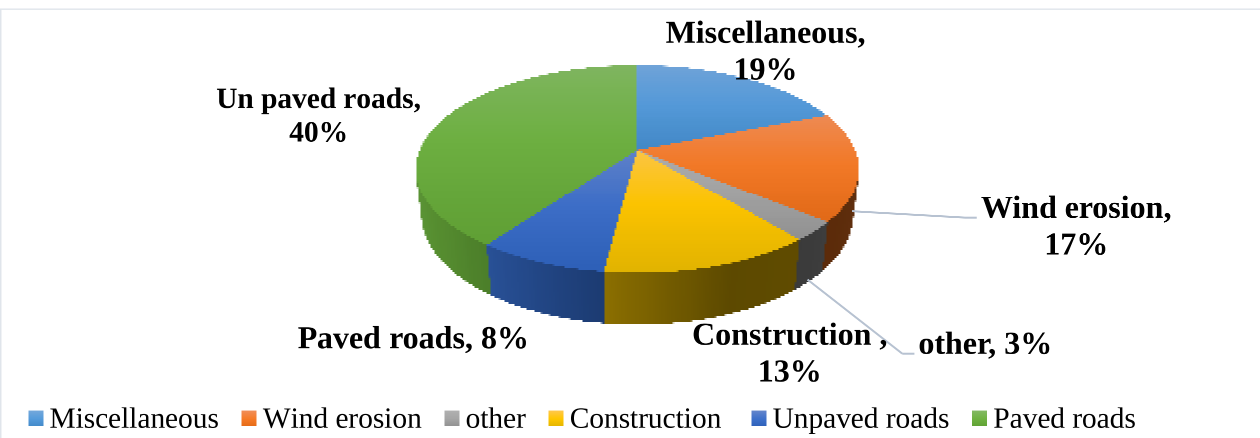

Figure .2. Composition of dust from different sources. Source: Environmental Protection Agency, (EPA, (2007) estimates.

Figure 2, shows dust composition from different sources. It can be seen that unpaved roads also generate quite a substantial amount of road dust. Various figures have been given for the amount of dust generated on gravel roads but the worldwide amount is thought to total over a billion tonnes annually. The mechanisms by which dust during road construction works is generated, transported and re-deposited have also been the subject of research, particularly in connection with the problems that can arise when exposed to it.

Mineral matter has been found to be an important component of urban PM_{10} particles in several studies around the world and its contribution can also be seen in the $PM_{2.5}$ size range as shown in several studies. A major source of mineral particles is estimated to be road dust, which has been acknowledged as a dominant source of PM_{10} (Pakkanen, et al., 2001).

Exposure to dust can be harmful to one's health. The health effects of both short (acute) and long term (chronic) exposure to road dust ($PM_{2.5}$ and PM_{10}) are well documented. Evidence is increasing for the adverse effects on health of fine particles ($<PM_{2.5}$), with short- term effects of $PM_{2.5}$ - PM_{10} being observed independently of the effects of $PM_{2.5.}$ In addition, there is increasingly strong evidence linking long- term exposure to PM_{10} with health effects, especially for respiratory outcomes. Coarse and fine particles deposit at different locations in the respiratory tract, have different sources and composition, act through partly different biological mechanisms, and depending on the physiology and age of the person result in different health outcomes, (WHO, 2005).

Several studies have shown that high road dust concentrations are usually a problem of urban areas and the effects of the dust on people exposed to it are a major source of concern. Exposure studies to mineral and resuspension particles in urban air have shown evidence of toxicity and a possibility of adverse health effects. Salonen, et al., (2004) found that resuspension particles caused pro inflammatory activity in cells due to their endotoxin concentrations and they hypothesized that this might be the reason for irritative symptoms in the respiratory system frequently reported by both asthmatic and healthy people during resuspension episodes.

Studies on the allergens in paved road dust have concluded that road dust contains biological materials capable of causing allergenic disease in humans. The possible symptoms a runny nose, watery eyes, and sneezing for larger sized particles, as well as swelling of lung tissue and asthma for fine particles. Apart from the discomfort and inflammatory responses caused by dust, respirable mineral particles, for example alumino silicates and crystalline quartz have been implicated in human disease, with lung cancer as the most severe consequence (Puledda, et al., 2000; Powell, 2002). These findings have been made with people exposed to very high concentrations of dust for long periods.

Yang et al., (2005) estimated similar associations between air particulate pollution (PM_{10} or $PM_{2.5}$) and hospital admissions for COPD that were reported for a variety of urban areas. A similar study by (Ayres, et al., 2008) revealed a growing epidemiological evidence which indicated that inhalation of airborne PM_{10} increases respiratory and cardiac mortality and morbidity, and produces a range of adverse respiratory health outcomes such as asthma, lung function decline, lung cancer, and chronic obstructive pulmonary disease. A cohort study of the American Cancer Society directly linked the particulate exposure to dust with lung cancer. For example, if the concentration of particles in the air increases by only 1%, the risk of developing lung cancer increases by 14% (Pope et al., 2002 and Kweskhi, et al., 2004).

Abo Shoga, (2014) in Nigeria also evaluated the level of PM_{10} air pollution in crusher's plants, and their impacts on respiratory system health, vital signs and complete blood count for crusher's workers, and found significant relationship between PM_{10} exposure and respiratory system symptoms. Namdeo and Bell, (2005) in Norway showed that several epidemiological studies have indicated a strong association between elevated concentrations of inhalable particles (PM_{10} and $PM_{2.5}$) and increased mortality and morbidity.

Studies in the road construction have also observed associations with wheeze and decrements in pulmonary function. In addition to the symptoms exposure to dust may also lead to serious respiratory diseases like the chronic obstructive pulmonary disease, pneumoconiosis and silicosis (Muneku, 2015).

Dust debris and fumes from the construction sites can wreak havoc on the lungs and cardiovascular system. Construction dust poses health risks because it often contains harmful substances like man-made mineral fibres, silica and cement residue. According to Dr. Manjula Jegasothy, a dermatologist at the Miami Skin Institute "dust from constructions may well cause more varied and severe allergies than dust generated from natural sources, such as animal hair and plant pollen," "This is because construction dust is often composed of particles from many different sources present at the construction site, coupled together, they irritate the skin and nasal membranes,". The combination of construction dust with a weak pulmonary function can result in severe attacks of asthma in construction workers.

The most controversial issue concerns whether only immunologically-mediated asthma should be considered to be occupational asthma or whether asthma arising as result of workplace exposure to irritants, or exacerbation of pre-existing asthma by work place irritants, should also be considered in the definition. The same also holds good for chronic obstructive pulmonary disease **(**COPD). However, it is left to the discretion of the researcher to use broader or narrower approach, though American Thoracic Society uses a broader approach for both with regard to occupation. Hence any new occurrence of COPD/Asthma after the joining of a job and its subsequent exacerbations during working years is taken as occupational unless there is strong evidence to prove that it is from other sources of exposure or other causes**.**

2.2.2. Coarse and fine particle deposition

Figure 3. Showing coarse and fine particle deposition

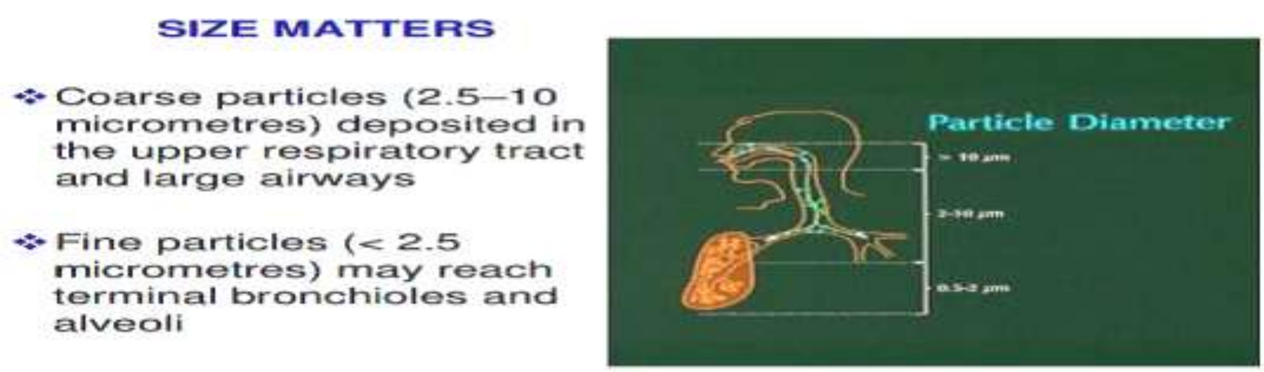

Figure 3. Coarse and fine particles deposition sites (WHO, 2005).

Figure 3. Shows the coarse and fine particles deposition sites. The figure shows that particles greater than 10 micrometres rarely make it past the upper airways, whereas fine particles smaller than 2 micrometres can make it as far as the alveoli (WHO, 2007). Particle size is the most important factor in determining where particles are deposited in the lung. Compared with large particles, fine particles can remain suspended in the atmosphere for longer periods and be transported over longer distances.

Dust from road constructions has a range of particle sizes from around 1μm to 100μm in diameter. However, in practice, particles with diameters greater than 20μm to 30μm do not last long in the atmosphere, as they tend to fall out rapidly and settle. The remaining PM_{10} and$PM_{2.5}$ are important from a health point of view because they are sufficiently small to penetrate the thoracic region of the lung (PM_{10}) and have a high probability of deposition in the smaller airways and alveoli ($PM_{2.5}$).

2.3. Factors associated with the occurrence of occupation respiratory health symptoms among the road construction workers

Apart from dust exposure, there are other factors (employee attributes) associated with the occurrence of respiratory symptoms. Muneku, (2015) report indicated that there are several factors that influence the effects of inhaled particles. Among these are some properties of the particles themselves. Particle size is usually the critical factor that determines where in the respiratory tract that particle may be deposited. Chemical composition is as well important because some substances when in particle form can destroy the cilia that the lungs use for the removal of particles, cigarette smoking may also alter the ability of the lungs to clear themselves. The Characteristics of the person inhaling particles can also influence the effects of dust. Breathing rates and smoking are among the most important. These factors are outlined as follows;

2.3.1. Social demographic characteristics

Socio-economic status is a determinant of health and is well known to play an important role in the development of several diseases, respiratory diseases among them. For example, age, and education are associated with adverse effects on respiratory health, with lower socio-economic status being associated with higher rates of morbidity and mortality from several chronic diseases, including cardiovascular disease, chronic obstructive and pulmonary disease (WHO, 2003).

2.3.1.1. Age and respiratory symptoms

Age is also an important factor that predisposes the exposure groups from having respiratory symptoms. Increased sensitivity with elderly people may be caused by diseases as a consequence of age. The prevalence of respiratory symptoms in some cases is assumed to increase with age (Simpere, 2010). An intensity of exposure, young children, pregnant women, the elderly, and individuals with chronic cardiopulmonary disease are particularly susceptible (Siziya, 2005).

2.3.1.2. Education and respiratory symptoms

Education is a key determinant of lifestyle and status an individual enjoys in a society and provide people with the skill and knowledge that can lead to a better quality of life (DHS, 2010). The low awareness of health and safety would make one more vulnerable to illness (Noor, et al., 2000). Respiratory health symptoms of both conditions are more prevalent among persons above 40 years of age and those with low levels of schooling as concluded in a study by (Osim, et al., 2004). Many workers are unaware of potential hazards present in their working environment, which let them to be more vulnerable to injury and other work-related diseases (Noor, et al., 2000).

2.4. Tobacco smoking and respiratory symptoms

The smoking of tobacco and its products has been recognized as a cause of respiratory impairment in Africa for a long time. In the1980s, the World Health Organization tried to focus on this but more recent studies showed that cigarette smoking was actually on the increase on the continent with attendant increase in respiratory morbidity (Tanmowo, 2000).

In a study by Siziya, (2005), it was shown that severe respiratory diseases could be prevented through the elimination of tobacco smoking. It was concluded in this study that tobacco smoke was found to potentiate the effect of dust on respiratory impairment. There was also association shown between lung function impairment and smoking

Studies from South Africa conducted by Sibongile, (2008) also demonstrated the continued deterioration in respiratory health from cigarette smoking, whether the smoking is active or passive. In addition, a cross sectional study in Jordan showed overall prevalence of respiratory symptoms of 42 percent and that of cough, dyspnoea and asthma were 18.7, 17.6 and 15.8 percentages respectively. The lung functions (FEV1, FVC and FEF-25/75) were affected with increasing age and smoking habit.

Ina similar study by Hnizdo, et al., (2000) in Canada, it was found that severe lung function impairment could be prevented through the elimination of tobacco smoking. It was concluded in this study that tobacco smoke was found to potentiate the effect of dust on respiratory impairment.

2.5. Years exposed to dust

Length of service is another factor that has been outline as one of an important contributing factor to the occurrence of respiratory symptoms. In a study conducted in Nigeria by (Osim, et al. 2004), it was also found that length of service was noted to be a predisposing risk factor for the occurrence of impaired breathing. Similar studies done in South Africa and few other developing countries showed an exposure-response relationship and also that job types and exposure to dust were significant predictors of lung function impairment (Gomes, et al., 2001).

2.6. Prevalence of Respiratory Symptoms

History of acute symptoms (phlegm, wheezing, shortness of breath, fever, stuffy nose, and skin itching/rash) following exposure to road dust is well known. These symptoms are relatively common reported at least one such symptom with exposure to road dust. Association of phlegm, wheezing, shortness of breath, and stuffy nose usually arise with the continuous exposure to dust. In addition, those who report wheezing on exposure to road dust may have an increased risk to develop chronic airflow obstruction. There is evidence that exposure to elevated levels of road dust is associated with respiratory symptoms and diseases.

Illnesses resulting from construction dust may lead to disability, sometimes even mortality. Murray and Lopez in their Global Burden of Disease (GBD-1990) project developed a model to assess the duration and the severity of morbidity and years of life lost per premature death. In their study, damages to human health attributable to specific diseases and injuries are expressed in terms of disability adjusted life years (DALYs). The DALY concept compares years of life lost and years of life lived with disability. Using disability adjusted life years, health can be treated as if it can be aggregated across individuals. For example, two people who each lose five years of disability-free life are treated the same as one person who loses ten years.

Most of such morbidity is in principal preventable with the help of the modern occupational health approach. Many of these cases of occupational symptoms however, go under diagnosed and under reported and preventive actions are not undertaken (WHO, 2010). It should be noted that the estimation of occupational disease rates is difficult because of the shortage of data and variation in the definition of an occupational illness in different countries.

A study carried out to assess the burden of occupational illnesses and associated factors in the Zambian workforce and the prevalence of work-related illnesses showed that chest infections were at 17% of the overall proportions in Zambia and was associated with significant levels of absence from work (Muula, et al., 2010).

Studies in the different regions of the world including; Asia, Africa and South America have shown that the incidence of pneumoconiosis may be increasing rather than decreasing (WHO, 2010). Further, studies done in different parts of the African region including; Nigeria, South Africa, and Ghana have shown that occupational respiratory symptoms are caused by inhalation of toxic dust and chemicals, Osim, et al., (2004).

A local study conducted by Jere, (2011) revealed that information obtained from central statistical office (CSO) of the government of Zambia showed that the prevalence of work related illness in Zambia was high and was associated with significant levels of absence from work. The data collected from 59,118 people over the age of 18 years from all the provinces of Zambia showed that 69% of the sample had suffered from occupational respiratory illnesses.

In a study by Gomes, et al., (2001), it was reported that the direct determinants of occupational respiratory symptoms are the occupational practices that increase the risks at work. These include; lack of training in occupational health safety, lack of personal protective devices, and long hours of work. In addition, Sabitu, et al., (2009) alludes that the indirect determinants of respiratory illnesses are the various macro-level or socio-economic and political factors that influence occupational health.

A WHO, (2005) report showed that the incidence of Pneumoconiosis (an occupational lung disease and restrictive lung disease caused by the inhalation of dust was still high. In 2013 globally Pneumoconiosis resulted in 260,000 deaths up from 251,000 in 1991. In Asia, Africa and South America occupational symptoms might be increasing, rather than decreasing. Although most of the reports are not verifiable statistically because of the difficulties in obtaining systematically gathered and relevant data, such accounts do underline the need for the widest possible dissemination of information relevant to the establishment of health-based limits for dust control.

In a study by Hnizdo, et al., (2003), it was shown that chronic levels of silica dust that do not cause disabling silicosis may cause the development of chronic bronchitis, emphysema, and or small airways illness that can lead to airflow obstruction. A study by Osim, et al., (2004) in Nigeria, it was further stated that there are 50 million occupational respiratory illnesses caused by inhalation of toxic dust and chemicals, which are allergenic and carcinogenic agents.

Occupation respiratory ill-health is a result of multiple etiological factors and this is difficultly when disentangling the influence of the various factors on the illnesses. The National Institute of Occupational Safety and Health, (2012) estimated that deaths from work-related respiratory diseases and cancers account for about 70% of all occupational diseases and death worldwide. Chronic obstructive pulmonary disease is a growing and leading cause of mortality, handicap and healthcare costs worldwide but remains largely under-diagnosed.

2.6.1. Chronic Obstructive Pulmonary Disease (COPD)

Intense and prolonged exposure to workplace dusts found in construction industry have been implicated in the development of airflow obstruction. They state that construction workers who are directly exposed to these particles and gases are even more likely to develop COPD. Intense silica dust exposure causes silicosis, a restrictive lung disease distinct from COPD; however, less intense Silica dust exposures have been linked to a COPD-like condition (Bergdahl, et al., 2004).

However, exposure to inorganic dust during construction especially on a construction site is now being researched as a major cause of COPD for the workers and the people living in the surrounding areas.

2.6.2. Silicosis

Crystalline silica is the basic component of sand, quartz and granite rock. Airborne crystalline silica occurs commonly both in and around construction work. Activities such as sand blasting, rock drilling, stone cutting, drilling, quarrying, brick/block/concrete cutting, asphalt paving, cement products manufacturing, demolition operations, hammering, chipping and sweeping concrete or masonry, and tunnelling operations can create a heavy airborne Silica exposure hazard as reported by the (Occupational Safety and Health Administration (OSHA), 2009). Occupational exposure and inhalation of airborne crystalline silica can cause Silicosis, a disabling, dust-related disease of the lungs. Even materials containing small amounts of crystalline silica may be hazardous if they are used in ways that produce high dust concentrations. Depending on the length of exposure, Silicosis is a progressive and many times a fatal disease that accounts for approximately three hundred deaths annually in the construction industry, or 15% of all Silicosis-cases result in deaths annually in both developed and developing countries as reported by the Occupation Health And Safety Agency (OSHA), (2009).

Symptoms of silicosis can appear from a few weeks to many years after exposure to silica dust. Symptoms typically worsen over time as scarring in the lungs occur. However, workers can prevent silicosis by limiting exposure. There are national guidelines on exposure limits over a lifetime of working. Patients with silicosis have an increased risk of other problems, such as tuberculosis, lung cancer, and chronic bronchitis.

Inhaling of Silica dust has also been associated with other diseases, such as Tuberculosis (TB) and Lung Cancer. There is no cure for Silicosis, but it is a 100% preventable occupational disease. In a study by Driscol, et al., (2005) to determine the global burden of non-malignant respiratory disease due to occupational airborne exposures, it was concluded that occupational airborne particulates (dust) are an important cause of death and disability worldwide. In an article on the elimination of Silicosis in (2005), it was noted at the 10th International Conference on Occupational respiratory symptoms and diseases (ICORD), the conference which provided an excellent forum for deliberations on best practices for prevention and control of occupational respiratory hazards. Silicosis is rampant in developing countries, developed countries like China which recorded more than 500,000 cases of Silicosis from 1991-1995 and in Brazil, the state of Minas Gerais alone had more than 4,500 workers with Silicosis due to dust exposure during this period, (Galloway, 2007). However, efforts are still needed to prevent Silicosis as it persists worldwide just like other respiratory illnesses (WHO, 2007). WHO, (2006) assumes road dust is in the particulate material (PM) size range from 1µm to 100µm in diameter. Williams, et al., (2008) measured dust generated on unpaved roads, the findings were particles in the size range from 0.05µm to 159µm. The samples were composed largely of silt and clay, dominated by the elements carbon, aluminium and silicon.

The United States Environmental Protection Agency (USEPA) estimates that PM10 is approximately 30% of total suspended particles and PM2.5 is approximately 10% of PM10 in fugitive dusts arising from unsealed roads). Studies in Britain surveyed dust from roads, finding 10% of PM up to 6μm in diameter, 15% of PM up to 10μm in diameter, and 60% of PM up to 25μm in diameter. Gunawardana, et al., (2012) characterized road dust from different land use types in Australia according to composition, in their study, they found that dust was composed of soil- derived minerals 60%, (including quartz 40–50%), clays from surrounding soils (38%) and 2% plant matter. They found soil- derived minerals containing iron, aluminium and manganese, with other metals – zinc, copper, lead, nickel, chromium and cadmium.

2.7. The impact of HIV and AIDS and occupational respiratory health symptoms among road construction workers

The Zambian Health Demographic Survey predicted that the prevalence of HIV among informal quarry stone crushers would increase steadily from 4.0% in 2006 to 6.8%by 2013. A similar study by Naidoo, et al., (2009), showed an association between HIV and TB among the stone crushers. The higher prevalence of doctor-diagnosed TB (13.0%) in the quarry workers in this study might reflect exposure to silica dust and the impact of human immune deficiency virus (HIV).

Literature suggests further that in most cases the road construction workers leave their homes to go and camp were the actual construction works are taking place. The sexual interactions in these camp areas in this particular group lead to rapid population-wide spread of HIV/AIDS. This kind of population intersection among road construction and maintenance workers creates “hot spots” of HIV/AIDS transmission. However, the current study did not explore the impact of HIV/AIDS on the study population due to personal sensitivities and costs.

2.8. Lung Function Capacity Test (Spirometry Test)

Numerous epidemiological studies have shown that respiratory symptoms, diseases and decline in lung function are associated with the elevated levels of dust. Many researchers have shown that the Particulate Matter (PM) of air pollution could affect the respiratory system especially for susceptible groups, where exposure to dust might decrease the lung function to different extents.

Spirometry is a simple test to measure how much (volume) and how fast (flow) one can move air into and out of the lungs. One of the benefits of spirometry testing (also referred to as "pulmonary function testing") is that it can detect abnormalities in lung function even when no signs or symptoms of disease are evident. Spirometry is recommended as the "gold standard" for the diagnosis of obstructive lung disease (Chisambi, 2012).

Dust particles which are inhaled are lodged in the lung and causes lung irritation, mucus hypersecretion initially, followed by lung function impairment, lung inflammation chronic obstructive lung disease, restrictive lung disease and pneumoconiosis and so on (Chisambi, 2012).

An example of this would be a cigarette smoker without shortness of breath who shows a mild decrease in airflow. In this case, the spirometry test detects disease at an early stage (before the onset of symptoms), so treatment (and smoking cessation, in this case) can be initiated earlier. Spirometry can also be used to help establish a medical diagnosis when signs or symptoms of disease are evident. An example of this would be a person who has developed wheezing. If decreased airflow is detected along with wheezing, this can be an indicator of asthma. Spirometry can also be used to assess the effectiveness of medical treatment, (Chisambi, 2012).

In a study by Chaldreen, (2012), it was indicated that pulmonary clearance becomes impaired after exposure to high dust concentration. It was concluded in this study that impairment of pulmonary clearance may affect all materials and species if dust is deposited in the lung at sufficient rate. In another study by (Osim, et al., 2004) to determine the lung function status as well as respiratory and other associated symptoms of Nigerian men and women chronically exposed to dust generated from the granite rock crushing industries (in Old Netim in Akampa local government area of the Cross River State) the study revealed that chronic exposure to dust does impair lung function and causes some respiratory and non-respiratory symptoms in men and women.

A Polish study by Izycki, (2000) that used a combination of questionnaire, chest x ray, clinical examination, spirometry, gasometry and capnographic tools, found 17 percent prevalence of chronic bronchitis, lower levels of arterial oxygen saturation (SPO2 < 90) and reduced lung volumes among the exposed workers.

The study in Nigeria by Oleru, (2004) found reduced lung volumes and higher prevalence of chronic bronchitis of those exposed to dust. Both of them were correlated with number of years of service among the exposed (cumulative effect). But the deterioration after 30 years of exposure was not marked. In occupational respiratory diseases, spirometry is one of the most important diagnostic tools. Measurement of dynamic lung functions is more important than of static lung volumes. Lung function tests are beneficial in the early recognition of pulmonary dysfunctions even if the workers may be normal clinically.

2.9. Assessment of Dust Control Methods

The Environmental Protection Agency (EPA, 2014) provides dust control measures applicable to any site where there is potential air pollution. The agency provides a comprehensive description of the methods available to control dust from unsealed roads. The key relevant dust control measures points of the methods used in dust control measures involve, elimination of dust, substitution, engineering and administrative control measures. Therefore the dust control measures can be described as follows:

1. Watering - the most used alternative due to its low cost of implementation and effectives if applied at least three times a day depending on the atmospheric conditions.
2. Mulch and vegetation– applied to protect exposed soil from wind erosion
3. Tillage - a control measure performed with chisel type plows on exposed soils.
4. Tackfiers and soil stabilizers- allows a new over the soil solving dust control problem on construction sites.
5. Chlorides - retains moisture for a long period preventing dust. The unique properties of chlorides help to hold down dust and stabilize unpaved roads and
6. Use of personal protective equipment (PPE) - helps to protect dust exposure to an individual. It is globally a key strategy to prevent or reduce workers dust exposure through the use of PPE. Although PPE is disputed in the hierarchy model for the reduction of occupation exposures, elimination, substitution, engineering and administrative control measure, PPE plays a very important role in protecting the workers from exposure. The use of PPE is often required as a safety measure. It is however, something of the ‘last

resort'. All other necessary measures must be taken into consideration before implementing PPE.

Therefore, assessment of dust control measure would mean assessing whether a construction site uses any of the above for control of dust. However, many studies in developing countries have shown to use only water to supress the dust as reported by (Muneku, 2015).

CHAPTER THREE

METHODOLOGY

3.1. Study Design

Cross sectional study measuring both the exposure (dust) and outcome of respiratory symptoms (wheezing, phlegm, shortness of breath and nose irritation) at the same time.

3.2. Study Site

Lusaka district, had been selected because there were numerous road construction works going on in the district, the district is located in Lusaka Province. As of the 2010 Zambian Census, the district had a population of 2,191,225 people.

3.3. Data Collection

The data collection tools were a structured interview questionnaire, personal dust sampler pumps and a Spiro bank G spirometer. Data was collected over a period of 8 weeks starting from the second week of September to the third week of November 2016.

3.4. Inclusion and exclusion criteria

The target population consisted of road construction workers in Lusaka and a total of 145 road construction workers were selected. Workers with a minimum of 1year work experience were sampled and these workers were 18 years and above. The study however excluded those with past medical history of serious respiratory illness.

3.5. Sample Size Estimation

During the pilot study there were a total number of 177 road construction workers. However, during the actual data collection 145 workers meet the inclusion criteria and were included in the study. Sampling with complete enumeration was done in order to have a better representation of the population. Therefore, using the formulae;

$n=Z^2PQ/d^2$; P=50%, and a non-response rate of 5%

$n=1.96^2 *0.5* (1-0.5)/0.05^2$

n=384.16 for an infinity population

s=n/ [1+ (n/population)]

s=384.16/ [1+ (384.16/285)]

s= 164.17 (adjusting foe 5% non-response rate)

s=164.17/0.95 = 1.76.81

s=1.77

3.6. Study variables

Table 1. Showing study variables and their scale of measurement

Type of variable	**Variable**	**Indicator**	**Scale of Measurement**
Dependent	Respiratory Symptoms	Presence of • phlegm • Wheezing • Nose irritation • Shortness of breath	Yes No **Nominal**

Independent Variable	1.Dust exposure levels 2. Utilization of PPE 3. Smoking 4.Years exposed to dust	Exposure Levels of dust Consistence use of • PPE • Safety boots • Face masks • Respirators • Goggles Tobacco use Years exposed to dust	>Threshold value < Threshold value **Categorical** Yes No **Nominal** Yes No **Nominal** 1-5years >5 years **Ordinal**

Table 1. Shows the study variables and outlines the scale of measurement for each variable.

3.7. Selection of Sampling Sites

Information was sought from Road Development Agency on the active road construction sites in Lusaka. Three sites were recorded to have active construction works and were selected for the study. Sampling with complete enumeration was done at all the three sites as all the workers meet the inclusion criteria.

3.8. Ethical Consideration

Ethical clearance for conducting the study was obtained in writing from the University of Zambia Biomedical Research Ethics Committee (UNZABREC) on the 23rd August 2017 (Assurance No. FWA 00000338, IRB 00001131 of IORG 0000774). An informed consent form was prepared according to the Research Ethics Committee guidelines; this was issued to the participants in order to guarantee voluntary participation, confidentiality, benefits and maintenance of privacy of all participants in the research. In addition, permission to conduct the research was also obtained in writing from the Lusaka City Council. Voluntary participation and the right to withdraw from the study at any time were emphasized. In order to ensure confidentiality, no names were recorded. The purpose and procedures of the study were explained to the participants. Time was given to them to ask questions or clarify anything. All the participants gave consent by signing and none used a thumb print. The data that was collected has been kept safely and will only be discarded after a period of about 5 years.

Precautionary measures in using the spirometer included the following; only one mouth piece was used by one participant to avoid cross infection and also because the survey was synonymous. The Principal investigator and trained technician wore appropriate P.P.E in order to protect themselves from any cross infection while the spirometry testing was being carried out.

3.9. Dust Collection

Dust was collected using personal dust sampler pumps with polyvinyl chloride filter membrane 37 millimetre in diameter and a pore size of 5 micro meter attached to the breathing zone of each road construction worker. Workers to be monitored were told the purpose of sampling and how the equipment was to be placed. The sampling equipment was calibrated and placed so that it does not interfere with the workers work performance. Sampling was achieved by turning on the pump and recording the starting time, Pump serial number, and sample number on the sample documentation form. Once the pump was started, it was observed for approximately 20 minutes and after every 2 hours to make sure that the flow rate of 2.5 litres per minute was maintained. This was attached to an individual for a total work shift of 8 hours.

In calculating dust concentrations, the difference between the weight of the filter paper before and after sampling, $\mathbf{W_1}$ before and after sampling $\mathbf{W_2}$ gave the weight of the dust, which accumulated during the sampling period. Dust concentration (DC) for each sampling time was calculated by dividing the volume, **V** into the weight of dust which accumulated **W**. Dust concentration was calculated in milligrams per litre (mg/l).

Sampling time was obtained by calculating the difference between the starting time, $\mathbf{t_1}$ and the ending time, $\mathbf{t_2}$. For the whole shift, therefore, time (min) = **t**, in expression is instead replaced by full shift (480 minutes, i.e. 8 hours' x 60 minutes) to convert to Time Weighted Average.

Time weighted average (TWA) (amount of dust exposure per eight-hour work shift, as an average of three samples) and cumulative dust exposure (multiplication of the number of years a person worked in a job category and the dust level measured for that particular job) were analysed between job categories. Which is; Cumulative respirable dust exposure =Σ [mean concentration of dust at (job) all jobs] x years of exposure.

3.10. Assessment of Respiratory Health Symptoms

Respiratory health symptoms were assessed using a modified American Thoracic Respiratory Questionnaire which was pre-tested and administered by the investigator. The questionnaire planned to capture nose irritation, phlegm, wheezing and shortness of breath. In this study phlegm refers to having phlegm on most days. Wheezing refers to chest ever sound occasionally apart from colds. Questions based on whether they usually have phlegm (Yes =1, No = 0), while for wheezing if ever chest sound (Yes = 1, No = 0), for nose irritation, having nose irritation (Yes =1 No = 0), and for breathlessness workers were asked whether they had trouble with shortness of breath when hurrying or walking up a slight hill (Yes =1, No = 0). The questionnaire was modified in relation to past respiratory illnesses before joining the road construction industry and past dust exposure. This was done for the purpose of exclusion and inclusion criteria.

3.11. Assessment of lung function

Lung function was measured using a spirometer on all the participants in the study. The tests were performed in accordance with the American Thoracic Society (ATS) guidelines for spirometry test. The participants were guided on the correct posture to take when doing the breathing manoeuvres to ensure maximum effort from the participant when they forcefully expired. Each worker was asked to inhale deeply to maximum lung capacity and exhale forcefully into the device. The lung function parameter that was recorded was forced expiratory volume in one second FEV1, forced vital capacity FVC and the ratio FEV1/ FVC. More specifically, the diagnosis of COPD is made when the FEV1/FVC ratio is <70%. According to the WHO, (2009) criteria, it is a value of FEV1% predicted that defines when a patient has COPD, that is, when FEV1% predicted is < 88% for men, or < 89% for women. Once airflow obstruction is established, the severity of the disease is classified by the reduction of FEV 1 compared with a healthy reference population as stipulated by Mannino, (2001) and Siziya, et al., (2005). The reference normal value that was used for spirometry testing was that of a normal person asper physiological standard where FEV1 /FVC% was 80% (Guyton, 2006).

The severity based on the FEV1 according to the American thoracic guidelines is classified as follows**: -**

- >80% predicted- Normal
- 70%-79% predicted-Mildly abnormal
- 60%-69% predicted- Moderately abnormal
- Very Severe COPD FEV1 < 30% predicted or < 50% predicted

3.12. Utilization of full Personal Protective Equipment (PPE's)

A checklist was also designed to assess the use of PPE's during working hours among the road construction workers, the principal investigator observed and interviewed respondent on the use of PPE (gloves, eye protection, foot protection, overall, helmet, mouth and nose protection, reflector coat and respirator).

3.13. Data Processing and Analysis

Data were entered and analyzed using Stata version 13. Frequency distribution, means (SD) and independent t-test were used for the continuous variables. The time weighted average as an average of three samples and cumulative respirable dust exposure (multiplication of the number of years a person worked in a job category and the dust exposure level measure for a particular job were analyzed. Fisher's exact test was used to test for associations between demographic characteristics, job category, cumulative respirable dust, use of PPE, smoking and years of exposure with respiratory symptoms. Logistic regression was used for crude and adjusted multivariate analysis. To test for normality Kolmogorov-Smirnov and Shapiro-Wilk tests were run. For all the analysis carried out, the statistical significance was achieved only when the P-value was less than 0.05 ($P < 0.05$).

3.14. Pretesting of data collection tools

Pretesting of data collection tools (Respiratory Health Symptoms Questionnaire) and (Spirometer) was done in order to determine its reliability in data collection. Though the spirometer and dust sampling pumps were validated and used in most studies, they were tested in a sample of 20.

3.15. Limitations

By design the current study was conducted as a cross-sectional study and therefore it could not establish causality and temporal sequence. In order to establish causality however, research in form of longitudinal studies would have to be conducted. For variables such as PPE (which includes frequency of use), questions on the behaviours and attitudes towards the same would be appropriate as opposed to questions phrased in a quantitative manner. It is further suggested that using qualitative methods of collecting data as opposed to quantitative methods would best to explore the possible associations that may exist among the variables of the study unlike the case in this current study.

The use of the structured questionnaire offered an opportunity for clarifying questions to the interviewee, but it also had some important limitations or disadvantages. The physical presence of the principal investigator during the data collection process may have influenced some responses and hence introduced some bias in the study. For instance, some of the participants if not most seemed to be worried about losing their jobs depending on the outcome of the study results. They all suspected that the results would be given to their superiors and hence they would later on end up losing employment. Despite informed consent being given, this did not still clear the doubt in the minds of some of the respondents. As interview schedule was the primary data collection tool, which required recall of information regarding the exposure, illnesses and PPE usage; the possibility of recall bias exists. Healthy worker bias could be another limitation since those who were severely ill could have died or left the job or shifted to other sections. Controlling for seasonal and other environmental interactions for causing the respiratory symptoms could not be done as well.

CHAPTER FOUR

RESULTS

4.1. Sample Description

The sample description showed that out of the initial expected sample size of 177 road construction workers, only 145 met the inclusion criteria. The distribution of workers from all the selected sites showed that construction site 1 had 52 (35.9%), construction site 2 had 50 (34.4%), and construction site 3 had 43 (29.7%) workers. The study population group comprised of males only.

Table .2. Showing the Frequency table for socio-demographic characteristics of study participants

Demographic characteristics	n=145	%
Age		
18-25 years	39	26.9
26-35 years	44	30.4
36-45 years	32	22.1
>45 years	22	20.7
Education		
No education	32	22.1
Primary	48	33.1
Secondary	43	29.7
Tertiary	22	15.2
Marital Status		
Not Married	45	31.0
Married	100	69.0

Table 2. Shows the frequency table for demographic characteristics (age, education and marital status). The results indicate that majority of the workers were aged between 26 and 35 years, (30.4%). Education showed more workers with primary education (33.1%) and marital status showed that there were more married men in the study (69%) as compared to those that were not married.

4.2. Dust exposure, time weighted average (TWA) dust concentration mean dust exposure range

Table 3. Showing the cumulative dust exposure levels and TWA dust concentration mean score per site (N=145)

Cumulative respirable dust concentration			
No of workers/site		**Mean(mg/m³/yr)**	**SD**
Site 1	52	1.766	0.568
Site 2	50	1.739	0.694
Site 3	43	1.804	0.635
overall	145	1.768	0.638

TWA dust concentrations in mg/m³ for the workers and job type		
	Respirable dust	**Total dust**
Site 1		
Land clearing	1.42	2.68
Mounting	0.98	1.76
Fine grading	0.63	1.14
Site 2		
Land clearing	1.21	1.63
Mounting	0.04	0.76
Fine grading	0.98	1.56
Site 3		
Land clearing	1.86	3.71
Mounting	0.52	1.28
Fine grading	0.76	1.56

Table 3. Shows results of the TWA cumulative respirable dust concentration results of the workers. The results indicate the overall time weighted average TWA cumulative respirable dust concentration exposure mean score of 1.768mg/m^3/yr. Comparison of the time weighted mean average shows that site 3 had the highest cumulative mean dust concentrations of 1.86mg/m^3/yr compared to site 1 with 1.42mg/m^3/yr and site 2 with 1.21mg/m^3/yr.

4.3. Prevalence of the respiratory symptoms

Figure 4. Showing the prevalence of respiratory symptoms phlegm, nose irritation, wheezing and shortness of breath

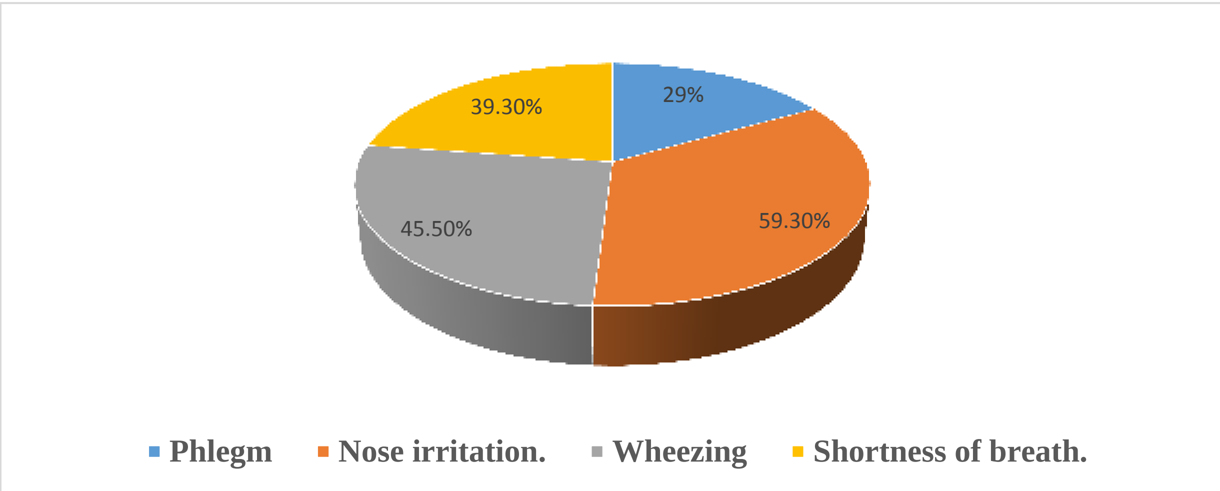

Figure 4. Shows that 29% of the workers experienced phlegm, 59% experienced nose irritation while 45% experienced wheezing and 39% experienced shortness of breath. Some of the workers reported having more than one symptom.

4.4. Assessment of dust control measures

The assessment of dust control measures revealed that only two methods were used as dust control measures and these were, use of personal protective wear and wet suppression. The personal protective wear provided to the workers were, gloves, work suits, googles, helmet, foot wear and respirators.

4.4.1 Use of full personal protective wear

The compliance to wearing full personal protective wear by the road construction workers revealed that out 145 workers only 63 of the workers adhered to the wearing of full personal protective wear. Most of the workers did not put on full personal protective wear as recommended by occupational health and safety laws.

Figure 5. Showing the proportion of utilisation of personal protective equipment among workers

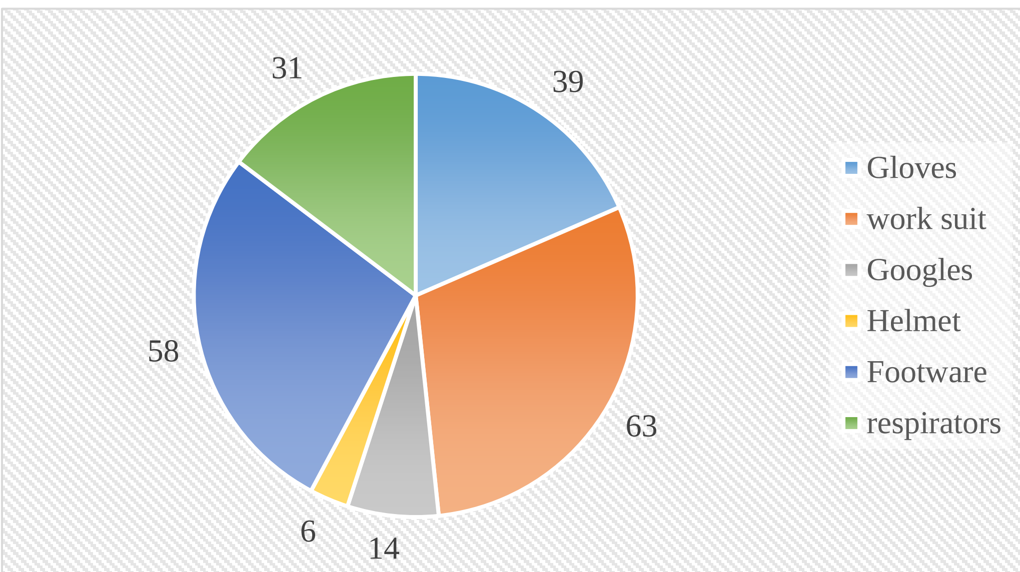

Figure .5. Shows the utilisation of Personal Protective Equipment (PPE) among the road construction workers. The results indicate that 39 workers wore gloves, 63 wore work suits, 14 wore goggles, 6 wore helmets, 58 wore footwear and 31 wore respirators.

4.4.2. Wet Suppression

Wet suppression was the other method used as a dust control measure. However, this study revealed that there was no consistence in spraying the ground with water as a result the method was ineffective as the workers were exposed to high dust levels when wet grounds dried up.

4.5. Bivariate associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory symptoms (phlegm, nose irritation, wheezing and shortness of breath)

Table 4. Showing the associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years of service with phlegm symptom

	Phlegm symptom				
	No		**Yes**		
Variables	**n**	**%**	**n**	**%**	**p-value**
Age					
18-25	12	19.0	27	33.0	
26-35	18	28.6	26	31.0	0.809
36-45	14	22.2	18	22.6	
>45	19	30.6	11	13.4	
Education					
No education	18	20.0	14	25.5	
Primary	29	32.2	19	34.5	0.436
Secondary	26	28.9	17	30.9	
Tertiary	17	18.9	5	9.1	
Job category					
Land clearing	56	62.2	23	41.8	
Mounting	20	22.2	22	40.0	**0.026***
Fine grading	14	15.6	10	18.2	
Cumulative respirable dust					
<1.768mg-yr/m^3	25	27.8	11	20.0	0.396
≥1.768mg-yr/m^3	65	72.2	44	80.0	
Use of PPE					
No	12	13.3	20	36.4	**0.002***
Yes	78	86.7	35	63.6	
Smoking status					
Does not smoke	50	55.6	26	47.3	0.425
Smokes	40	44.4	29	52.7	
Years exposed					
1-5 years	64	71.1	38	69.1	0.943
>5	26	28	17	30.9	

Table 4. Shows the associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory phlegm symptom. The results show a significant association between job category (p-value 0.026) and personal protective equipment (p-value 0.002) with respiratory phlegm symptom. There was no association between age, education, cumulative respirable dust, smoking and years exposed, with respiratory phlegm symptom.

Table 5. Showing the associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with nose irritation symptom

	Nose irritation symptom				
	No		Yes		
Variable	**n**	**%**	**n**	**%**	**p-value**
Age					
18-25 years	18	29.0	21	25.3	
26-35 years	12	19.4	32	38.6	0.549
36-45 years	19	30.1	13	15.7	
>45 years	13	21.0	17	20.4	
Education					
No education	13	20.6	19	23.2	
Primary	17	26.9	31	37.8	0.164
Secondary	23	36.5	20	24.3	
Tertiary	10	15.8	12	14.6	
Job category					
Land clearing	20	33.9	19	45.3	
Mounting	19	32.2	24	27.9	**0.013***
Fine grading	20	33.9	23	26.8	
Cumulative respirable dust					
<1.768mg-yr/m^3	16	27.1	20	23.3	0.739
≥1.768mg-yr/m^3	43	72.9	66	76.7	
Use of PPE					
No	9	15.3	23	26.7	0.151
Yes	50	84.7	63	73.3	
Smoking status					
Does not smoke	34	57.6	42	48.8	0.383
Smokes	25	42.4	44	51.2	
Years exposed					
1-5 years	41	69.5	61	70.9	0.999
>5	18	30.5	25	29.1	

Table 5. Shows the associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory nose irritation symptom. The results show that there was a significant association between job category (p-value 0.013) with respiratory nose irritation symptom. There was no association between age, education, cumulative respirable dust, use of PPE, smoking and years exposed with respiratory nose irritation symptom.

Table 6. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with wheezing

	Wheezing symptom				
	No		Yes		
Variable	**n**	**%**	**n**	**%**	**p-value**
Age					
18-25 years	12	20.3	27	31.4	
26-35 years	14	23.7	30	34.9	0.571
36-45 years	16	27.1	16	18.6	
>45 years	17	28.8	13	15.1	
Education					
No education	15	19.4	17	25.0	
Primary	23	29.9	25	36.8	0.719
Secondary	25	32.8	18	26.5	
Tertiary	14	18.2	8	11.8	
Job category					
Land clearing	31	51.7	37	54.1	
Mounting	27	45.0	46	43.5	0.544
Fine grading	2	3.3	2	2.4	
Cumulative respirable dust					
<1.768mg-yr/m^3	24	32.4	12	16.9	**0.049***
≥1.768mg-yr/m^3	50	67.6	59	83.1	
Use of PPE					
No	10	13.7	22	31.0	**0.020***
Yes	60	86.5	49	69.0	
Smoking status					
Does not smoke	37	50.0	39	54.9	0.669
Smokes	37	50.0	32	45.1	
Years exposed					
1-5 years	51	68.9	51	71.8	0.840
>5 years	23	31.1	20	28.2	

Tables 6. Shows associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory wheezing symptom. The results show that there was a significant association between cumulative respirable dust (p-value 0.049) and use of PPE (p- value 0.020) with respiratory wheezing symptom. There was no association between age, education, job categories, smoking and years exposed with respiratory wheezing symptom.

Table 7. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years of service with Shortness of breath

	Shortness of breath				
	No		Yes		
Variable	**n**	**%**	**n**	**%**	**p-value**
Age					
18-25 years	15	23.8	24	36.9	
26-35 years	21	33.3	23	35.4	
36-45 years	14	22.2	18	27.7	0.547
>45 years	13	20.6	17	26.1	
Education					
No education	17	20.0	15	25.0	
Primary	27	31.8	21	35.0	0.706
Secondary	26	30.6	17	28.3	
Tertiary	15	17.6	7	11.7	
Job category					
Land clearing	35	47.2	35	46.5	0.608
Mounting	38	38.8	33	49.3	
Fine grading	1	1.4	2	4.2	
Cumulative respirable dust					
<1.768mg-yr/m^3	27	31.8	9	15.0	**0.035***
≥1.768mg-yr/m^3	58	68.2	51	85.0	
Use of PPE					
No	12	14.1	20	33.3	**0.011***
Yes	73	85.9	40	66.7	
Smoking status					
Does not smoke	50	58.8	26	43.3	0.095
Smokes	35	41.2	34	56.7	
Years exposed					
1-5 years	64	75.3	38	63.3	0.171
>5	21	24.7	22	36.7	

Table 7. Shows associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory shortness of breath symptom. The results show that there was an association between cumulative respirable dust (p-value 0.035) and use of PPE (p- value 0.011) with respiratory shortness of breath symptom. There was no association between age, education, job categories, smoking and years exposed with respiratory shortness of breath symptom.

4.6. Multivariate associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory symptoms of phlegm, nose irritation, wheezing and shortness of breath

Table 8. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with phlegm, (n=145)

Variable	OR	95%CI	p-value	AOR	95%CI	p-value
Age						
18-25	1.042	0.508-2.137	0.763	0.996	0.467-2.123	0.991
26-35	1.238	1.873-1.955	0.527	0.922	0.535-6.835	0.318
36-45	1.253	0.759-1.651	0.164	2.819	0.771-8.300	0.211
>45	1					
Education						
Primary	2.644	0.783-8.934	0.117	2.165	0.548-8.549	0.270
Secondary	2.228	0.703-7.055	0.173	2.931	2.931-1.958	0.110
Tertiary	2.223	0.690-7.160	0.181	1.992	0.521-7.613	0.314
No education	1					
Job category						
Land clearing	0.436	0.220-0.865	0.018	0.665	0.278-1.588	0.358
Mounting	0.636	0.287-1.502	0.319	0.037	0.301-1.346	0.238
Fine grading	1					
Cumulative respirable dust						
≥1.768mg-yr/m^3	0.650	0.290-1.455	0.295	1.563	0.550-4.439	0.402
<1.768mg-yr/m^3	1					
Use of PPE						
No full PPE	3.714	1.637-8.427	0.002	1.256	3.526-3.384	**0.007***
Full PPE	1					
Smoking						
Smoker	0.717	0.366-1.887	0.333	1.448	0.622-3.373	0.390
Non smoker	1					
Years exposed						
>5years	0.908	0.437-1.406	0.796	1.745	0.703-4.332	0.230
1-5years	1					

Table 8. Shows the associations of demographic characteristics, job category, cumulative respirable dust exposure, use of personal protective equipment and years exposed with respiratory phlegm symptom. The results show that there was a significant association between non-use of full personal protective equipment, with the development of respiratory phlegm symptom (OR 1.256; 95%Cl, 3.526-3.384), (p-value 0.007). Workers who did not use full PPE were 1.25 times likely to develop respiratory phlegm symptom than those who used full PPE.

There was no significant association between age, education, job category, cumulative respirable dust, smoking and years exposed with respiratory symptom phlegm.

Table .9. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with nose irritation, (n=145)

Variable	OR	95%Cl	p-value	AOR	95%Cl	p-value
Age						
18-25	0.853	0.442-1.667	0.652	0.853	0.419-1.736	0.661
26-35	0.645	0.558-1.931	0.264	0.684	0.226-2.073	0.502
36-45	0.369	0.066-0.609	0.021	0.326	0.107-1.993	0.149
>45	1					
Education						
Primary	0.341	0.095-1.225	0.099	0.383	0.108-1.354	0.136
Secondary	0.515	0.152-1.749	0.288	0.518	0.153-1.758	0.291
Tertiary	0.229	0.066-0.798	0.021	0.257	0.076-0.862	**0.028***
No education	1					
Job category						
Land clearing	2.345	0.143-0.831	0.018	2.382	0.159-0.919	**0.032***
Mounting	1.720	0.632-2.173	0.321	0.631	1.665-5.621	0.931
Fine grading	1					
Cumulative respirable dust						
≥1.768mg-yr/m^3	0.908	0.143-0.831	0.820	1.167	0.403-3.378	0.776
<1.768 mg-yr/m^3	1					
Use of PPE						
No full PPE	1.149	0.421-3.141	0.786	1.242	0.460-3.352	0.669
Full PPE	1					
Smoking						
Smoker	0.810	0.360-1.823	0.610	0.875	0.391-1.960	0.746
Non smoker	1					
Years exposed						
>5years	1.188	0.511-2.762	0.689	1.213	0.525-2.799	0.652
1-5years	1					

Table 9. Shows the associations of demographic characteristics, job category, cumulative dust exposure, use of personal protective equipment and years exposed with respiratory symptom nose irritation. The results show that there was a significant association between workers with tertiary education and respiratory nose irritation symptom (OR 0.257; 95% Cl 0.076-0.8623), (p-value 0.028) and job category (land clearing) (OR 2.832; 95%Cl 0.159-0.919), (p-value 0.032). Workers with tertiary education were 74% less likely to develop nose irritation as compared to workers with primary and secondary education. In addition workers who were involved in job category (land clearing) were 2.3 times more likely to have nose irritation as compared to workers doing mounting and fine grading. There was no significant association between age,

cumulative respirable dust, use of personal protective equipment, smoking and years exposed with respiratory nose irritation symptom.

Table .10. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with Wheezing, (n=145)

Variable	OR	95%Cl	p-value	AOR	95%Cl	p-value
Age						
18-25years	1.257	0.653-2.422	0.494	1.155	0.576-2.315	0.686
26-35years	1.331	0.835-2.183	0.379	0.818	0.226-2.518	0.461
36-45years	0.419	0.561-1.983	0.368	0.333	0.169-1.879	0.318
>45years	1					
Education						
Primary	0.833	0.281-2.474	0.743	0.514	0.158-1.672	0.269
Secondary	0.906	0.329-2.493	0.848	0.855	0.280-2.611	0.784
Tertiary	0.600	0.213-1.689	0.333	0.517	0.169-1.586	0.249
No education	1					
Job category						
Land clearing	1.295	0.672 - 2.494	0.440	1.571	0.647-3.813	0.318
Mounting	0.467	0.672 - 1.326	1.460	0.532	1.837-3.239	0.084
Fine grading	1					
Cumulative respirable dust						
≥1.768mg-yr/m^3	0.424	0.193-0.932	0.033	1.211	0.426-3.443	0.719
<1.768 mg-yr/m^3	1					
Use of PPE						
No full PPE	2.873	1.247-6.623	0.013	3.755	1.416-1.958	**0.008***
Use of full PPE	1					
Smoking						
Smoker	1.219	0.634-2.341	0.553	1.343	0.604-2.985	0.469
Non smoker	1					
Years exposed						
>5years	1.150	0.563-2.348	0.701	0.752	0.327-1.730	0.503
1-5years	1					

Table 10. Shows the associations of demographic characteristics, job category, cumulative dust exposure, use of personal protective equipment and years exposed with respiratory symptom wheezing. The results show that there was a significant association between non-use of personal protective equipment and respiratory wheezing symptom (OR 3.755., 95%CI, 1.4I6 -1.958), (p-value 0.008). Workers who did not use full PPE were 3.7 times more likely to wheeze as compared to those who wore full personal protective equipment. There was no significant association between age, education, job category, cumulative respirable dust, smoking and years exposed with respiratory wheezing symptom.

Table 11. Showing associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with shortness of breath, (n=145)

Variable	OR	95%Cl	p-value	AOR	95%Cl	p-value
Age						
18-25years	1.307	0.667-2.539	0.440	1.365	0.683-2.729	0.379
26-35years	1.667	0.576-4.825	0.346	1.117	1.724-3.707	0.831
36-45yeas	1.401	0.473-4.149	0.543	1.175	1.856-4.007	0.797
>45years	1					
Education						
Primary	1.891	0.608-5.879	0.271	1.904	0.559-6.481	0.303
Secondary	1.667	0.576-4.825	0.346	1.551	0.477-5.048	0.466
Tertiary	1.401	0.473-4.149	0.543	1.468	0.452-4.770	0.523
No education	1					
Job category						
Land clearing	0.519	0.266-1.015	0.055	1.099	0.470-2.570	0.827
Mounting	0.345	0.428-1.218	0.086	0.862	0.582-1.985	0.762
Fine grading	1					
Cumulative respirable dust						
≥1.768mg-yr/m^3	1.379	0.163-0.881	0.024	1.317	0.125-0 .802	**0.015***
<1.768 mg-yr/m^3	1					
Use of PPE						
No full PPE	3.042	1.349-6.857	0.007	1.512	0.601-3.803	0.380
Full PPE	1					
Smoking						
Smoker	0.535	0.274-1.045	0.067	0.831	0.381-1.812	0.641
Non smoker	1					
Years exposed						
>5years	0.567	0.276-1.165	0.122	0.666	0.299-1.485	0.320
1-5years	1					

Table 11. Shows the associations of demographic characteristics, job category, cumulative dust exposure, use of PPE and years exposed with respiratory symptom shortness of breath. The results indicate that there was a significant association between respirable dust levels ≥1.768mg-yr/m^3 and respiratory shortness of breath symptom (OR1.317; 95%Cl 0.125-0.802), (p-value 0.015). Workers exposed to dust levels ≥1.768mg-yr/m^3 were 1.3 times more likely to develop shortness of breath as compared to workers exposed to levels <1.768mg/m^3. There was no significant association between age, education, use of PPE, smoking and years exposed with respiratory shortness of breath symptom.

5.7. The spirometry test results

Table 12. Showing the spirometry test results of the workers (N=145)

Percentage predicted FEV1 Value	Results	No of workers per predicted value
80% or greater	Normal	139
70-79%	Mildly abnormal	4
60-69%	Moderately abnormal	2
50-59%	Moderately to severe abnormal	Nil
35-49%	Severely abnormal	Nil
Less than 35%	Very severely abnormal	Nil

Table 12. Shows the spirometry test results. The results show that out of the 145 workers, 139 had normal lung function, 4 of the workers had mildly abnormal lung function and 2 had moderately abnormal lung function. The predicted values and results were outlined according to the American thoracic society guidelines.

CHAPTER FIVE

DISCUSSION

Most studies that have looked at dust exposure levels and factors associated with the respiratory symptoms among workers in Zambia focussed mainly on the mining industry. This study shifted focus from assessing the dust exposure levels found in the mining industry to dust exposure levels in the road construction industry and factors associated with the occurrence of respiratory symptoms among workers.

5.1. Cumulative respirable dust exposure levels

The overall mean cumulative respirable dust level was 1.768mg/m^3. The time weighted mean dust concentrations showed that study participants at site 3 had the highest respirable mean dust concentrations exposure of 1.94mg/m^3. The recommended exposure limit in Zambia is 1.74 mg/m^3. Therefore the dust exposure levels in this study were slightly above the recommended limit in Zambia.

Respirable dust concentrations in this study differed substantially from concentrations found in a similar study in the Tanzanian stone crushers of 0.5 mg/m^3 to 2.8mg/m^3. However, a similar study in Indian quarries reported eight-hour TWA concentrations of respirable dust of 39.7 mg/m^3, (Green, et al., 2008). These findings were 30 times higher than the dust concentrations found in this study.

Green, et al., (2008) also reported dust levels of 68.0 mg/m^{3}and 18.9 mg/m^3 for total inhalable and respirable dust, respectively. The respirable dust levels were 17 times higher than the Occupational Exposure Limits (OELs) set in Zambia of 1.74mg/m^3.

A study conducted in a cement factory in the United Arab Emirates (UAE), concentrations of total dust ranged from 4.2mg/m^3 in crushers to 15.2 mg/m^3 in the packaging areas. The values exceeded the Occupation Exposure Limit (OEL) set by the American Conference of Government

Industrial Hygienists (ACGIH) of 10 mg/m^3 in the packaging and raw mill areas (Ahmed, et al., 2012).

Another study conducted in Tanzanian stone crushers also showed that the respirable dust exposure concentrations ranged from 0.6mg/m^3 in administrative workers to 54.7mg/m^3 in crane operators, with 39% of dust samples exceeding the ACGIH limit of 10 mg/m^3, Naidoo, et al., (2009). This study reported respirable dust levels from area sampling among Tanzanian stone crushers ranging from 0.1mg/m^3 in loading to 2.8 mg/m^3 in crushing activities. These dust levels in this study are almost similar to the dust levels in this study.

However, in my study, 55% of the workers were exposed to respirable dust levels above the recommended exposure limit value of 1.74mg/m^3. This was mainly due to poor dust control measures at the sites and workers' poor compliance to wearing of full personal protective equipment.

In addition, in this study multivariate associations showed that exposure to a cumulative respirable dust concentration of $\geq$1.768mg/m^3-yrs was significantly associated with shortness of breath (OR1.317; 95%CI; 0.125-0.802, p-value 0.015). The cumulative dust exposure results were similar to the findings of Masoud, et al., (2011) which revealed that there is an association between dust exposure and respiratory symptoms such as wheezing, nose irritation and shortness of breath.

In another similar study by Hafiz and Abdelridha, (2012), cough and phlegm had a significant association with dust exposure. A study by Sitambuli, (2011), in Tanzania also concur with the results of my study suggesting a strong association between dust and the respiratory symptoms of nose irritation (p-value 0.001) and wheezing (p-value 0.003).

In addition a similar study by Muneku, (2015), in Zambia also showed a significant association between dust exposure and respiratory phlegm symptom.

However, some studies are known to contradict the findings of my study. A study conducted in South Africa by Sibongile, (2008) showed no association between dust and the respiratory symptoms but showed a significant association between dust and the use of PPE indicating a (p-value 0.002), job category (p-value 0.014) and duration of exposure (p-value 0.043).

5.2. Prevalence of respiratory symptoms

The prevalence of respiratory symptoms among workers in the road construction industry were, phlegm 29%, nose irritation 59.3%, wheezing 45.5% and shortness of breath 39.3%. In general the prevalence of the respiratory symptoms among workers exposed to dust in other industrial activities which generate dust seem to be much lower to what has been found in the road construction industry.

A study by Ansari, (2017), in Bangladesh among the rice millers found that a total of 34.0% of workers complained suffering from the symptoms of chronic respiratory illness. Cough (18.0%), dyspnoea (10.0%), rhinitis (6.8%) and wheezing (5.8%) were the prevalent symptoms.

A similar study by Ghasemkhani, et al., (2005) among workers exposed to industrial dust in industries in south Tehran in Iran found a high prevalence of respiratory symptoms among the workers of cough 20.7%, phlegm 41.6%, dyspnoea 41.7%, chest tightness 27.4% and nose irritation 23.5%.

In addition, a study by Chen et al., (2005) among the steel workers also revealed that the prevalence of respiratory symptoms was, chronic cough (14.6%), chronic phlegm (11.9%), wheezing (2.6%) and shortness of breath (6.5%).

Therefore, the findings of this study found the prevalence of occupational respiratory health symptoms to be relatively higher than the findings from other studies.

5.3. Factors associated with the occurrence of the respiratory symptoms among road construction workers

The predisposing factors to having the respiratory symptoms taken into account in this study include, age, education, job category, use of PPE, smoking and years exposed. These factors are outlined below.

5.3.1. Age

Age is one of the factors that has been highlighted in several studies to be a predisposing factor to one having occupational respiratory symptoms when exposed to workplace dust. In this study however, there was no significant association between age and the occurrence of respiratory symptoms. This contradicts the findings of the studies by Aude, et al., (2011), who found that respiratory symptoms were reported more among workers above 40 years of age as compared to other age groups. A similar study by Ghasemkhani, et al., (2005) also concluded that the age of a worker was significantly associated with the occurrence of respiratory symptoms. In addition, Chaldreen, (2012) adds on to say, the effects of ageing on the respiratory system are similar to those that occur in organs as maximum function gradually declines with age. In most cases ageing comes with a decrease in peak airflow and gas exchange and decreases in measures of lung function such as vital capacity and the maximum amount of air breathed out.

5.3.2. Education

Education is another attribute that has been mentioned to have an impact on dust exposure and the development of the respiratory symptoms especially among those with lower levels of education. In this study, those with tertiary education were less likely to suffer from occupational respiratory health symptoms. This could be that workers with tertiary education are able to understand the benefits of using control measures such as the use of personal protective wear.

A study by Sabitu, et al., (2000), concurs with my study it was reported that only 20% of the workers who had no formal education were aware of occupational hazards and safety measures compared to 77.6% among those who had primary education and 85% among those who had secondary education.

A study by Nandi, et al., (2009) reported that among the measures to use for control of the work environment in order to help reduce morbidity among miners, health education was a priority. It has been shown in the literature that educational level and avoidance of occupational hazards are positively associated. It is also noted in this study that those with tertiary education were less likely so suffer from respiratory symptoms which also agrees to the other scholars' findings.

In addition, Muula, et al., (2010) reported that lower education level was positively associated with more likelihood of suffering from an occupational illness. He further stated that respondents with higher levels of education were less likely to suffer from illnesses compared to respondents with lower levels of education.

5.4. Job category

Job category (land clearing, mounting and fine grading) was to found to be significantly with the development of respiratory phlegm symptom (p-value 0.026) and nose irritation respiratory symptom (p-value 0.013). Multivariate association showed that workers in land clearing (high dust areas) were 2.3 times more likely to develop nose irritation symptoms (AOR 2.382, 95%Cl, 0.159-0.919), (p-value 0.032). Respiratory wheezing symptom (p-value 0.544) and shortness of breath (p-value 0.608) were not significantly associated with job category.

A study by Gholami, and Kakooei, (2012) found high dust levels at the earth works sections" which was in the line with the "high dust units" and showed that the workers who worked in these sections were exposed to high dust levels. The study also indirectly confirms the above findings.

5.5. Use of personal protective equipment

The study showed that use of PPE was significantly associated with the development of phlegm (p-value 0.002), wheezing (p-value 0.020), and shortness of breath (p-value 0.011).

Multivariate associations showed that workers who did not use full PPE were 1.3 more likely to develop phlegm symptoms (p-value 0.007), 3.8 times more likely to develop (wheezing p-value 0.008). However, non-use of PPE in the study was not significantly associated with nose irritation respiratory symptom (p-value 0.151).

A study by Nandi, et al., (2009) and Al-Nealmi, et al., (2001) stated that among the measures for the control of dust in the workplace environment, use of PPE would help reduce morbidity resulting from dust exposure. None of these studies stated explicitly if PPE was associated with respiratory symptoms. However, in the current study the wearing of boots was mandatory and was highly insisted upon and monitored. Other than the wearing of boots, the compliance to the regular use of eye goggles, gloves and facemasks or respirators was poor for half of the labourers.

This also gives a valuable indication that without necessary organizational will and standards, compliance to PPE cannot be satisfactorily achieved.

Two additional factors which influenced the use of PPE were identified. One of the factors which workers stated was that PPE was uncomfortable and unnecessary. The other factor indicated was that the workers were in most cases not provided with PPE. This highlights the need to explore the attitudes and the practices of the workers according to their own perceptions (emic perspective) so that interventions can be made that are worker friendly and implementable without resistance.

In addition, during the study two other points were also noted worth reporting. Most of the workers used a cloth similar to a towel as the mask and most of them said that there were too few masks that were available for use in each section compared to the number of workers who needed them at a time.

However, exposure to dust can be prevented by workers wearing full protective wear. This will also prevent the workers from the prevalence of respiratory symptoms due to dust exposure. In addition, any future study in a similar situation should explore the worker's attitude and knowledge towards the use of full protective wear.

5.6. Smoking

Tobacco smoking is also another factor attributed to the occurrence of respiratory symptoms. However, this study showed no significant association between tobacco and any of the respiratory symptoms. A study by Siziya, (2005), also found no significant association between smoking and the occurrence of respiratory symptoms.

The role of smoking being a confounder had been squarely ruled out by regression analysis itself. The findings in this study were contrary with the evidence from dust related literature, which mentioned smoking as a positive "effect modifier" for dust induced respiratory symptoms and diseases as shown by Blanc, et al., (2009).

However, a study by Shiffman, et al., (2004) showed several lines of evidence to suggest that cigarette smoking alters the respiratory tract's ability to defend itself from infection. Some subjects with chronic bronchitis have colonization of the lower respiratory tract with bacteria. Both patients with chronic respiratory disease and healthy smokers appear to have a higher frequency of respiratory infections and an increased severity of symptoms when infected.

A study by Hughes, et al., (2009) showed a marked variability in the incidence of infection in the smoking population suggesting that there are subtle factors that predispose some smokers to more risk of infection than others. It revealed that cigarette smoking is associated with alterations in mechanisms of the respiratory defence system, even in asymptomatic individuals.

In addition, several studies suggest that smoking has adverse health effects on the entire respiratory system affecting every aspect of lung structure and function including impairing the lung defence mechanism against infection and causing the sustained lung injury that leads to chronic obstructive pulmonary disease (COPD). In fact, among the postulated causes of COPD are acute respiratory infections, for which smokers are at high risk.

5.7. Years exposed

Years exposed to dust is one factor that is seen to have an impact on the health of workers. However, this study did not find any significant association between years exposed and the prevalence of respiratory symptoms. These findings also agree with the study findings by Siziya, (2005) which also showed no significant association between duration of exposure and the development of respiratory symptoms.

However, findings by (Osim, et al., 2004) were contradictory to the findings in this study as it was reported that length of service was a predisposing risk factor for the occurrence of impaired breathing and also that the prevalence of respiratory symptoms increased with the duration of work and the exposure to dust respectively. These contradictory findings may be due to the differences in length of employment between the study sites. Other explanations could be that some of the workers had a non-continuous long duration of working due to job terminations then re-hiring at unfixed interval, contracts, and also job rotations in general.

A study done in China to assess quality of life for Silicosis by using St George respiratory questionnaire showed that patients with longer duration of exposure had higher total scores of respiratory impairment, Nurs, et al., (2012). This simply entails that the longer an individual stays in employment, the higher the chances of suffering from occupational respiratory illnesses and other respiratory complications. It is therefore advisable that workers adhere to safety standards in order to protect themselves from dust exposure and the respiratory symptoms and the diseases that may occur thereafter.

5.8. Assessment of dust control measures

In this study only two methods of dust control being practiced at all the three road construction sites were assessed and these were, wet suppression of dust and the use of personal protective equipment.

5.8.1. Wet suppression of the dust

Wet suppression as a dust control method is simple and faster, however, as assessed the method turned out to be effective only for shorter periods of time, after a few hours water dried up and workers were still exposed to the dust as there was no consistence in the spraying of water. Wet suppression is typically the least expensive and easiest to design and implement however this method requires both prevention and suppression to effectively control dust.

5.8.2. The use of personal protective equipment

The use of personal protective equipment was also another method that was used to control the dust exposure. However, the findings were that most of the workers did not put on full protective wear. Most of the workers wore gum boots as compared to the other protective equipment, respirators, eye googles, gloves, helmets and work suits. This simply shows that there was poor adherence to the use of full protective equipment.

Therefore, the two measures used in the dust control did not prove to be effective in the control and suppression of dust.

Finally, the current dust control practices as assessed do not prove to be effective in dust control. Therefore, it is important that effective dust control measures are put in place like embracing the use of chlorides and other dust suppression solutions that have proved to be more efficient and effective in other regions as compared to the use of water which has been outline as just a temporal measure.

5.9. Spirometry test (Lung function value FEV1/FVC percent)

There was insufficient evidence to the association between spirometry and the occurrence of respiratory symptoms considering the majority of the workers (96%) had normal lung function capacity despite being exposed to dust. The possible reasons to this are that the majority of the workers were not consistently exposed to dust as they were working in shifts and were working mostly on contracts were there services were stopped and renewed. In short the majority of the workers were not continuously engaged to do the road construction works.

However, on the contrary similar studies in Norway and Iran at cement industries revealed that workers exposed to dust had a decrease in lung function Meryl, (2006). The current study also contradicts the findings of Chisambi, (2012) in a study to determine the prevalence and correlates of lung function impairment among Open-pit miners of one of the oldest and largest Open-pit mines in Zambia. The prevalence of impaired lung function among the miners due to dust exposure from the mines showed that 3.3% of the miners had severe lung function impairment, 4.1% had moderate impairment, and 19.7% had mild lung function impairment).

As a part of respiratory protection program in dust industries (as per Occupation Safety and Health Administration) in Zambia and other international bodies like Health Safety Executive in Britain), it becomes the duty of employer (public or private)to ensure that the workers in such industries undergo medical check-ups or respiratory examination that includes clinical examination to full range of Spiro metric tests once in three years at least so as to detect any symptoms or diseases which may result due to dust exposure. In any case spirometry test should be encouraged as it is able to detect the symptoms and diseases in the early stages.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The study presents the assessment of dust exposure levels and factors associated with the occurrence of respiratory symptoms. The study shows that the mean cumulative respirable dust exposure levels slightly exceeded the occupation health exposure limit (1.74mg/m^3) recommended under the Occupation Health and Safety Act No 36 of 2010 of the laws of Zambia. In addition, the occurrence of respiratory symptoms phlegm, nose irritation, wheezing and shortness of breath were relatively high in the study. Apart from dust exposure, education, job category, use of PPE and years exposed facilitated the occurrence of respiratory symptoms. The dust control measures used in the road construction industry are not sufficient and effective to curb dust exposure among the workers. Therefore, the findings of the study are of importance in that they demonstrate the extensive need for preventive measures of dust exposure. In addition to this, the study also highlights the need for active preventive occupational health interventions in the road construction industry, which must address the implementation of health and safety policies and appropriate workplace dust controls measures in order to reduce workers exposure to dust and the outcome of respiratory symptoms.

6.2. Recommendations

The study looked at dust exposure levels along with risk factors in a broader public health perspective, so that the points of intervention at various levels could be identified. The approach, therefore to the current problem has to be multi-dimensional aimed at tackling all levels of determinants of the adverse outcomes. Therefore, below are the recommendations.

1. The Engineering Association of Zambia should regulate Engineering controls measures for dust reduction at industry and should be a crucial intervention from water to palliative materials including brines, solution based on sodium chloride (Nacl), calcium chloride (Cacl) and magnesium chloride $mgcl_2$.

2. Legal enforcers should ensure that they provide proper health education, surveillance of workplace air quality and personal dust exposure, management of illness and rehabilitation would be an altruistic approach and also provide a strategy to ensure workers compliance to personal protective equipment.

3. Ministry of Labour and Social Security (MLSS) should develop laws to protect the road construction industry and protect the workers from the damage from the pollutants and also develop recommendations and requirements of engineering and environmental appropriate to each industrial activity.

4. Ministry of Health should ensure that they provide Occupational Health Surveillance tools including routine health check-ups and lung function assessment.

5. Ministry of Health should conduct Pre-employment medical examinations workers exposed to dust. This should include a base line clinical examination of the respiratory and cardiovascular system with pulmonary functions testing and arterial blood gases monitoring, chest X-ray to exclude workers with chest problems.

6. Another study to be repeated in future, however the size of the study population and the time that participants are monitored should both be increased if possible, thus allowing a larger data set to work with, which would allow a more in-depth analysis.

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APPENDICES

Appendix .1. Information sheet

THE UNIVERSITY OF ZAMBIA

BIOMEDICAL RESEARCH ETHICS COMMITTEE

(UNZABREC)

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Assurance No. FWA00000338

IRB00001131 of IORG0000774

STUDY TITLE: **ASSESSMENT OF DUST EXPOSURE LEVELS AND FACTORS ASSOCIATED WITH THE OCCURRENCE OF RESPIRATORY SYMPTOMS AMONG ROAD CONSTRUCTION WORKERS IN LUSAKA DISTRICT, ZAMBIA.**

Principal Investigator:

UNZA Biomedical Research Ethics Committee No…………………….

I Nsunge Nsofwa, student of Master's Degree in Public Health at the University of Zambia is requesting for your participation in the study mentioned above. The centre of the study is to assess dust exposure levels and factors, respiratory symptoms and factors associated with the occurrence of respiratory symptoms among the road construction workers in Lusaka, Zambia. I will explain to you the purpose of the study and what is expected of you. Firstly, your participation in this research is voluntary. I will be asking some questions on your health and also doing a short blowing manoeuvre with a small tube like apparatus for you to test your lung function. There is absolutely no harm associated with the procedure. On the whole it will take 30 to 45 minutes of your time. Your participation is very valuable because the answers you give will be used to represent other people like you in industries. The information you will provide will not be disclosed to any one and will only be used for study purpose. If you agree, you will be requested to sign the consent form.

Purpose of the Study

The study will assess dust exposure levels, prevalence of respiratory symptoms and factors associated with the occurrence of respiratory symptoms in the road construction industry in Lusaka district in Zambia. The information that will be collected will assist in understanding the effects of dust and will enable the policy makers to improve on occupational dust exposure.

Procedures

For each construction site workers will be interviewed if they consented to participate in the study. Know that by participating you are representing your site.

The questions will be about dust exposure and respiratory symptoms in the road construction industry. There is no right or wrong answer to the questions you will be asked and the answers are valued.

Benefits

There may be no direct benefit for you by participating in this study, but the information which will be obtained will help policy makers formulate policies on occupational dust exposure.

Factors associated with the occurrence of respiratory

There will not be any bodily harm or lose of any provision for participating in this study however during interviews there may be some questions that may seem to be invading on your privacy and part of your time from the busy schedule will be used. The interviews will not take more than 30 minutes.

Payment

There is no payment for participating in this study.

Confidentiality

What you will tell me will not be revealed to anyone and will be treated as confidential; the information will be kept under lock and key. No name, address, and other personal information will be entered on the questionnaire. If any abnormality is detected by above means it will be reported to your physician and if necessary referral to the nearby government facility will be done for the benefit of your health. All the above help will be provided to you after you are willing to reveal the illness to your physician and also willing for taking treatment.

Appendix 2. Consent form

THE UNIVESITY OF ZAMBIA

SCHOOL OF MEDICINE

DEPARTMENT OF PUBLIC HEALTH

P.O. BOX 50110

CONSENT FORM FOR PARTICIPATION IN RESEARCH

An assessment of dust exposure levels and factors associated with the occurrence of respiratory symptoms among road construction workers Lusaka, Zambia.

I ……...Being above the age of 18 years hereby consent to participate as requested in this study.

- I have read the information provided.
- Details of procedures and any risks have been explained to my satisfaction.
- I agree to audio/video recording of my information and participation.

4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.

5. I understand that:

- I may not directly benefit from taking part in this research.
- I am free to withdraw from the project at any time and am free to decline to answer particular questions.
- Individual information and identity will remain confidential even if this study will be published
- The interview may be stopped at any time and without any disadvantage related to with draw from this study.

6. The purpose of this study has been explained to me and I understand the purpose, benefits, discomfort, and confidentiality of the study.

I agree/do not agree to participant in the research.

Participant's signature……………………………………Date…………………...

Participant's signature or thumb print

I certify that I have explained the study to the participant and consider that he/she understands what is involved and freely consents to participation.

Researcher's name……………………………….……………………….................

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

If you have any questions, concerns and clarifications, contact the University of Zambia Research Ethics Committee on the following addresses:

Call me, << Nsunge Nsofwa>>, at << +260- 977311032>> if you have questions concerning this study.

Contact the University of Zambia Biomedical Research Ethics Committee Office for any ethical queries. The Ethics Committee contact information is:

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Assurance No. FWA00000338
IRB00001131 of IORG000077

Appendix 3. Individual checklist

Sn	Type of PPEs	Wearing of PPE'S during working.		
		Answer		
		0 = No	1 = Yes	Explanation
1	Respirator			
2	Hand gloves			
3	Eye protection /goggles			
4	Foot wear (boots)			
5	Clothing/apron/overall			
6	Reflectors			
7	Helmet			
8	Nose/mouth masks			

Appendix 4. Questionnaire

Respiratory symptoms interview questionnaire for road construction workers in Lusaka District.

Date of interview……………………… Questionnaires number …………
Name of interviewer……………………

Instructions

- **Where boxes are given, enter details expect for in the coding box**
- **Where options are given, tick () where applicable**

Social demographic factors

S/n	**Question**	**Coding**	**Response**
1	Sex: (by observation)	0 = Male	
		1= Female	
2	Age …………………………………………. years		
3	Marital status	1 = Single	
		2 = Married	
		3 = Divorced	
		3 = Cohabiting	
		4 = Widow	
4	Level of education	**1 =** No education	
		2 = Primary education	
		3 = Secondary education	
		4 = Tertiary education	

5	When did you start this job? ……………………………………..years.
6	How long in this job? …………………………………….years.
7	How many working hours per day? …………………………… hours.
8	How many working hours per a week? ………………………. hours.
9	What is your working time? …………………….to …………. hours.
10	Weight …………………………..kg
11	Height ……………………….cm

Respiratory symptoms

S/N	**Question**	**Coding**	**response**
1	Do you usually have a cough? If NO Skip to 3	0 = No	
		1 = Yes	
2	Do you usually cough as much as 4 to 6 times per a day or 4 days more out of a week?	0 = No	
		1= Yes	
3	Do you usually cough at all?	0 = No	
		1 = Yes	
4	If yes to any above (1, 2, 3, 4). Answer the following. If not to all Check does not apply and skip to next section...........		
5	Do you usually cough like this for 3 consecutive months or more during the year?	0 = No	
		1= Yes	

6	For how long you had this cough? ……………………………...years

Phlegm

SN	**Questions**	**Coding**	**Response**
1	Do you usually bring up phlegm from your chest?	0 = No	
		1 = Yes	
2	*If NO skip to question no 3..................*		
3	Do you usually bring up phlegm like this as much as twice a day, or four days more out of the week?	0 = No	
		1= Yes	
4	Do you usually bring up phlegm at the all during the rest of the day or at right?	0 = No	
		1 = Yes	
5	*If yes to any above (1, 2, 3,). Answer the question 4 and 5...................*		
6	Do you bring up phlegm like this on most days for 3 consecutive months during the year?	0 = No	
		1 = Yes	
7	For how many years have you had trouble with phlegm? ....years		

Wheezing and nose irritating

Sn	**Questions**	**Coding**	**Response**
1	Does your chest ever sound wheezy or whistling? 1. When you have a cold	0 = No	
		1 = Yes	
		0 = No	

2	2. Occasionally apart from colds	1 = Yes	
3	3.Most days or night	0 = No	
		1 = Yes	
4	*If YES part 1, 2 or 3 in question 1 go to question 2 …………………*		
5	For how many years has this been sound wheezy present? ....years		
6	Do you have nose irritate?	**0 = No**	
		1 = Yes	
7	For how many years has this been nose irritating present? ....years		
8	Do you sneezing once you start working?	**0 = No**	
		1 = Yes	
9	For how many years has this been sneezing present? ....years		

Shortness of breath

SN	Question	Coding	Response
1	Have you trouble by shortness of breath when hurrying the level or walking up a slight hill?	**0 = No**	
		1 = Yes	
2	For how many years have you had trouble for shortness of breath?...............................years		

OCCUPATIONAL HISTORY

SN	Questions	Coding classification	response
1	Have you ever worked for any other dusty job?	0 = No	
		1 = Yes	
2	Specify job ...., industry/area......................................		
3	For how long? …………………………………years		
4	What perceived level of dust has been exposed in that job?	Mild = 1	
		Moderate = 2	

PAST RESPIRATORY HISTORY

	Questions	Response

SN				
	Was either of your past life ever told by a doctor that you had a chronic lung condition as mentioned below?	**0**	**1**	**2**
1	Chronic bronchitis			
2	Emphysema			
3	Asthma			
4	Heart attack.			
5	Lung cancer.			
6	Tuberculosis (TB)			

NOTE: 0 = No, 1 = Yes, 2 = Don't now

Adopted from: American Thoracic Society (ATS) (Recommended for assessing Respiratory Symptoms (1978).