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ASSESSMENT OF DUST EXPOSURE AND RISK OF CHRONIC RESPIRATORY DISEASES AMONG STONE CORRIE QUARRY WORKERS IN NAMIBIA, 2018

By

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DECLARATION

I, Saima Shihepo hereby declare that the work contained in the thesis entitled Assessment of Dust Exposure and Risk of Chronic Respiratory Diseases among stone corrie quarry workers in Namibia is my own original work and that I have not previously in its entirety or in part submitted it at any university or other higher education institution for the award of a degree.

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LIST OF ABBREVIATIONS/ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienist's
ANOVA	Analysis of variance
COPD	Chronic Obstructive Pulmonary Disease
FVC	Forced Vital Capacity
FEV	Forced Expiratory Volume
NAMAGRA	Namibia Marble and Granite
NIOSH	National Institute for Occupational Health and Safety
PLE	Permissible Limit of Exposure
PTB	Pulmonary Tuberculosis
PBZ	Personal-Breathing-Zone
RCS	Respirable Crystalline Silica
REL	Recommended Exposure Limit
SPSSS	Statistical Package for Social Sciences
TLV	Threshold Limit Value
TWA	Total Weight Average
WHO	World Health Organisation
XRFS	X-Ray Fluorescence Spectrometry

ABSTRACT

Quarry mining produces substantial dust amounts bearing an adverse effect on human health in several ways, mainly the respiratory system. Even though employers are obligated to protect their employees from occupational hazards, the quarry mining industry in Namibia has failed to honour that obligation. This study investigated quarry workers and the surrounding community's exposure to dust as well as their risk of getting chronic respiratory diseases in the Erongo region of Namibia.

Objectively the study assessed the amount of silica emitted in quarry dust emissions from selected Namibian quarry mines in compliance with national and WHO Air Quality Standards. Secondly, this study made an evaluation of health risks connected to dust exposure amid quarry workers and surrounding communities of 1km radius to selected quarry sites. Lastly, this study established appropriate interventions to deter dust exposure effects on quarry workers and the surrounding community.

A cross-sectional descriptive study was done with 233 quarry workers and community members from selected quarry mines around Karibib. Self-administered interview questionnaires were used to both quarry workers and community members. Respirable dust levels were evaluated in different work stations using Spirometry. Binominal logistic regression analysis was used to predictable the overall outcome of quarry dust exposure on respiratory outcomes, while linear regression predicted the exposure-related effect on lung function. Workers were stratified according to the cumulative dust exposure category.

The highest mean dust level, by quarry site, was 1.13 mg/m^3 (SD: 0.58) recorded among workers from Site A and the lowest was 0.63 mg/m^3 (SD=0.38) at Site B. In relation to job types, excavation had the highest mean dust level of 1.20 mg/m^3 (SD: 0.65) and wire saw the lowest at 0.54 mg/m^3 (SD=0.42). The most prevalent of the respiratory symptoms reported by the quarry workers were coughing (57%) and the corresponding percentage among the community members was lower (14%).

There were more respondents with 10 or more years in quarrying (78%) who reported coughing compared to 58% or less among workers with less than 10 years in the job. Statistical links between the lung function assessments and quarry site, job specification, or years in quarrying among the quarry workers ($p>0.05$) were not established. Lung function outcomes between the quarry workers and community members ($p>0.05$) did not also show a substantive difference. However, a significant statistically difference between quarry workers and community members, with 13 of the 120 of quarry

workers (11%) diagnosed with obstructive or restrictive lung functioning compared to none of the 96 community members. There were statistically significant associations between smoking history and the lung function assessments FVC1 Pred% and FEV1 Pred%. Workers with 6-10 years of smoking history had significantly lower mean scores on both these measures compared to non-smokers.

The study found that there were no medical examinations records at any of the studied sites. The study recommended that routine occupational medical check-up is performed for each and every worker of the quarry mines. Environmental administration systems, such as dust management plan, can be used in quarries to minimise the generation of dust. Regular environmental audit and monitoring of quarrying activities should be enforced in order to ensure adherence to the standards and limits of the concentrations of the dust generated from the different stages of their operations.

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CHAPTER ONE: BACKGROUND TO THE RESEARCH

1.1. Introduction

The global population is largely represented by workers who contribute to the socio-economic development of the modern society of which Namibia is no exception. Despite the crucial role played by the working population, a considerable part of Sub-Saharan Africa workers' general morbidity is attributed to the poor work environment, limited access to occupational health and safety services, exposure to harmful occupational related gasses, fumes, diseases and accidents (WHO, 2006). However, the International Labour Organisation's Promotional Framework for Occupational Safety and Health Convention, 2006 (No.187) mandates states and organisations in both public and private sectors to uphold a healthy and safe working environment which prevents occupational illnesses, accidents, injuries and fatalities (ILO, 2006).

This study focused on workers in the Namibian Quarry Mining Sector. Quarry mining in Namibia is an important business sector as it employs a significant population as well as contributing to the country's Gross Domestic Product (GDP). The National Planning Commission (2015)), reports that the mining and quarrying sector contributes 11.7 percent to the Namibian GDP. According to the Chamber of Mines of Namibia (2012), mines and exploration companies directly or indirectly employ over 100 000 people, which is a significant figure considering the country's population of 2, 3 million. Sufiyan and Ogunleye (2013) state that quarry workers specifically bear a higher risk of being exposed to respirable dust, thereby posing a serious health threat.

Momyer (2016) confirms that there is a strong relationship between dust exposure and an increase in respiratory symptoms among quarry workers. In addition, Esswein, Kiefer, John, Snawder, and Breitenstein (2012) found out that about 11 percent of asthma and 13 percent of entirely all enduring obstructive pulmonary disease (COPD) picked among quarry workers were associated with exposure to fine dust.

In support of Momyer's (2016) and Esswein et al.'s (2012) findings, health surveillance on quarries located in the Erongo region of Namibia revealed that respiratory indications like persistent coughing and phlegm, breathlessness as well as wheezing relate to individual quarry employees who were prone to dust exposure.

Quarry mining consists of a series of interconnected processes from extraction, drilling, crushing, sorting, transportation and secondary stage processing, which all generate dust that is detrimental to health. Reduced lung function, cardiopulmonary failure and lung cancer are some of the common symptoms linked to respirable dust that has penetrated deep into the lungs and blood circulatory system (Miller, et al., 2005). Long periods of exposure to the high amounts of respirable fine dust particles such as crystalline silica can lead to death (Naidoo Robins, Seixas, Lalloo, & Becklake, 2006). After an extensive literature search, no study findings of quarry workers' and community members' health assessment has been done in Namibia. In light of this, the current research study aimed at evaluating health risks and respiratory diseases occurrences within quarry workers and surrounding community workers as a result of dust exposure.

1.2. Problem statement

Respirable dust particulates from quarry mines pose a serious concern as they are greatly connected to deadly occupational respiratory conditions and diseases like lung cancer, pneumoconiosis, chronic asthma and tuberculosis (Esswein et al., 2012). The incidence of bronchitis, emphysema, silicosis, and lung cancer by quarry workers resulting from dust exposure were reported in Nigeria (Nwibo, Ugwuja, Nwambeke, Emelumadu, & Obgbonnaya, 2012).

Despite ILO mandates states and organisations to adhere to occupational health and safety legal provisions, some quarrying mines in Erongo, which is the main focus of this study, tend to disregard the safety measures of employees due to the profit maximisation objective. Thus, the majority of quarry mines have inadequate occupational safety measures and systems, which have led to an increase in respirable dust exposure resulting in respiratory diseases and decreased lung functions among quarry workers (Suhr, Bang, & Moe, 2007). Naidoo, et al (2006) reported decreases in FEV 1 of up to 27.5 ml/mg-year/m^3 among new miners while a 15-year cumulative exposure related to declines of 5.9 ml in FEV 1 per mg-year/m^3.

A study by Henneberger and Attfield (1996)) showed that causal mine workers had increased dust related adverse effects on FEV 1 as compared to permanent workers. New quarry miners' FEV 1 was affected than old miners due to their unaccustomed exposure tooccupational silica dust. According to Reindel and Goldsmith (2011), the more time an individual is exposed to dust, the more their FEV1, FEC and PEFR is decreased. Thus, the more time exposed to dust the more chances of severe obstruction. Nwibo et al. (2012) noted a high prevalence of the following respiratory problems; sporadic chest pain (47.6%), sporadic cough (40.7%) and blood-stained sputum (0.5%).

In the Namibian context, national statistics indicate ever increasing occupational respiratory conditions within quarry workers mainly attributed by noncompliance with OHS provisions by the mining companies in the Erongo Region. Other than quarry workers, community members have also become victims of respiratory conditions and disorders due to being exposed to dust from surrounding quarry activities. This study therefore sought to investigate the risk of respiratory diseases in stone quarrying mines and the surrounding community in Namibia and suggest possible interventions.

1.3 Aim/Purpose of research

The study objective was to measure the level of dust exposure and assess the risk of chronic respiratory conditions and disease within quarry workers and the surrounding community in Namibia.

1.3.1 Specific objectives

These included:

1. To establish the content and level of respirable dust from selected Namibian quarries in compliance with national and WHO air quality standards.
2. To evaluate respiratory health effects associated with respirable dust exposure among quarry workers and surrounding communities which are within a 1km radius of selected quarry sites.

1.4 Research questions

The study sought to answer the following questions:

1. What are the levels of respirable dust exposure within Namibian quarry workers and elemental characteristics of dust emissions from each selected quarry sites?
2. What are the possible health impacts resulting from dust exposure to quarry workers and the surrounding community?
3. What is the awareness level of quarry workers and the surrounding community with regards to occupational dust exposures?
4. What interventions are identified to curtail the adverse effects of quarry dust emissions?

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter gives insights into related literature with a supporting theoretical basis for the study. Included in the chapter is the conceptual framework addressing the problem under investigation.
The study adopted the differential susceptibility theory (DST) which strives to understand why some social groups are more susceptible to diseases (risk-promoting) and death due to complexities of interactions in the environment, behaviour and lifestyle (Last, 1998). In this study, stone quarry workers were considered susceptible to their working environment; as a result, the DST assisted in revealing the risk of poor respiratory health outcomes amongst quarry workers.

2.2. Workers' exposure levels to respirable dust

Employers are obligated to the levels of respirable dust within work stations so as to ensure that current exposure levels do not exceed the standard or legal permissible levels (Babatunde, 2013). Assessing the level of exposure enables the employer to determine workers' risk for exposure as well as come up with appropriate control measures which safeguard the employee. Epstein (2018) points out that by establising the employee's exposure levels to respirable dust, employers are able to indentfy job catergories with highest exposure thereby devoting more effort and resoruces to such areas.

2.2.1 Respirable dust exposure levels at different sites

Due to the difference in the geological structure of the earth's crust, different sites bear different amount of dust level exposure.
In Mumbai, India, quarry operations produces high concentrations of respirable dust, containing very high silica content amounting up to more than 75% (Bradshaw, Bowen, Fishwick, & Powell, 2010). Thus, quarry workers were exposed to an estimated 2.93inghn3 of respirable dust on their daily eight-hour shifts. The amount that was reported in Mumbai is greatly above the standard permissible limit of exposure (PLE) of 0.36ingirn3 (Fulekar, 2008). Ringen and Englund (2009), attribute increased exposure to respirable dust due to lack of access to information and awareness of occupational health services, safety facilities and inadequate training on respiratory health and safety.

NIOSH sampled 11 different hydraulic fracturing sites to evaluate worker exposure to crystalline silica (Esswein et al, 2012). Results of the sample sites revealed full-shift personal-breathing-zone (PBZ) exposures to respirable crystalline silica which consistently exceeded relevant occupational health criteria. At these sites, 54 (47%) of the 116 samples collected exceeded the calculated OSHA PELs; 92 of 116 (79%) exceeded the NIOSH REL and ACGIH TLV (Esswein et al, 2012). The magnitude of the exposures is particularly important; 36 of the 116 (31%) samples exceeded the NIOSH REL by a factor of 10 or more (Esswein et al, 2012).

A study by Kwaansa-Ansah, Kwaku Armah and Opoku (2017) in Ghana on quarry mines established mean concentrations of respirable dust from four different locations ranging from 0.02-4.26 mg/m3. From the four locations, the highest location (Shaft A) recorded a mean concentration of 1.07 while the least location (Shaft D) recorded a mean concentration of 0.88 mg/m3. According to Merenu, Mojiminiyi, Njoku and Ibrahim (2007), for the National Institute for Occupational Safety and Health, the standard for respirable dust is pegged at 1.0 mg/m3. Thus, from the same study, Shaft A (1.07 mg/m3) and Shaft B (1.06 mg/m3) surpassed the NIOSH recommended respirable dust exposure limits.

A study by Hamatui, Naidoo, and Kgabi (2016) showed that charcoal dust exposure levels exceeded the US OSHA endorsed limit of 3.5 mg/m^3 with factories 1 and 3 bearing the peak dust levels. Females from factory 1 recorded 25.9 mg/m^3 and factory 3 bearing 19.4 mg/m^3 which was the highest dust exposure compared to other factories. This trend denoted a very high risk of exposure to respiratory health effects which implies that charcoal workers had a very high risk of developing abnormal pulmonary functions as well as respiratory symptoms. A study by Nwibo et al. (2012) demonstrated varying silica content in dust from the three different rock types assessed. From the rocks assessed for silica, pozzolana was highest with 35.92%, limestone was the least with 3.26%. Overall, silica concentration was 0.62mg/m3 which is more than the recommended OSHA limit of 0.2mg/m3. In this regard, quarry workers had a high risk of developing respiratory health effects (mainly silicosis) due to their exposure. In Ghana, Kwaansa-Ansah et al. (2017) found the mean concentration of silica crystalline for four sites ranging from 0.02 to 1.03 mg/m3. Among the four sites, the peak site (Shaft C) recorded a mean concentration of 0.19 ± 0.25 mg/m3 of silica, while the least site (Shaft D) recorded an average of 0.13 ± 0.13 mg/m3. This means that Shafts C and D exceeded the NOISH standard exposure limits (0.1 mg/m3) for and crystalline silica.

2.2.2 Respirable dust exposure levels by job category

Work within job categories is unlike due to the nature of activities being carried out. Some jobs they emit a lot of dust as compared to others.

Esswein et al (2012) points out that removal of overburden during quarry activities is the first operation. Kulkarni (2007) calculations came up with a total of 660 kg of dust per day which was generated during the removal of overburden removal in Indian quarry mines.

Results of a study by Sufiyan and Ogunleye (2013) indicated that the majority (41.9%) of the respondents worked for 1-5 years, with 85.1% working for 5-7 days in a week and 81.0% working for 5-12 hours per day. This day-work profile of 25-84 hours per week, with an average of 54.5 hours is quite demanding compared to the United Kingdom report in which quarry workers work for 37.5 hours a week with a considerable amount of overtime. Long work-hours mean long exposure time to respirable dust at the workplace. In the same study, 6.8% of the respondents were involved in machine operation and this indicates that a lot of manual work goes on in the quarries. Manual work places a higher demand on the workers than does mechanized work, requiring more energy input as well as more time to do the same thing, thus accounting for a high proportion of exposure to respirable dust hence increasing the risk of manual workers developing respiratory diseases.

Kwaansa-Ansah et al. (2017)'s study findings revealed that the minimum dust concentration for all job categories (Teledyne Operators, Equipment Operators, Long Hole Drillers Blast men, Machine Drivers and Grouters) was below the NIOSH recommended value. Blastmen recorded a minimum concentration range of 0.3346 ± 0.118 mg/m3, whereas Teledyne Operators recorded the least range (0.2 23 ± 0.125 mg/m3) for respirable dust.

Study results by Kumar et al. (2014) showed an increased incidence of respiratory health effects at quarry sites, with the crusher recording the highest compared to other job categories. Olusegun, Adeniyi and Adeol (2009) revealed that excavation generated high dust amounts in comparison to other selected jobs within the quarrying sites. The increase in dust content was attributed to drilling and the mobility of machinery during the mining processes. Draid, Bn-Elhaj, Ali, Schmid, and Gibbs (2015) revealed that the crusher had the highest dust concentrations compared to other job categories.

Drilling generates considerable amounts of dust during quarrying as, Merenu, et al (2007) estimated 20-25 mg m^{-3} of dust released from drilling and 15-30 mg m^{-3} from overburden removal in open cast coal mining.

Studies conducted by Suhr, Bang, and Moe (2007) in Turkey on loading section realised respirable dust of 0.1–3.5 mg m^{-3} which was more than 2 mg m^{-3} of the international permissible limit. Aloh (2008) found out that respirable emission rates of 0.6 g s^{-1} for coal loading and 0.2 g s^{-1} for iron loading. In the same study, unloading reported higher emission rates ranging from0.8–1.4 g s^{-1} and 0.5 g s^{-1} for coal and iron respectively.

2.2.3 Respirable dust exposure levels due to distance from source

Moreover, Sumana, Jemima, Rani and Madhuri (2016) established varying levels of dust concentrations as the distance from the source either increased or decreased. The mean dust concentration levels from the source at 0m was 0.165mg/m3, at 200m it was 0.04mg/m3 and at 500m it was 0.005mg/m3. In the study, a negative correlation coefficient affirmed a reduction in dust concentration levels as the distance from the source increased as well. The decrease in dust concentration due to the increase in distance from the source is as a result of the dilution effect caused by the wind. The more distance travelled by dust particles, the more they become diluted by wind action. Results by Babatunde (2013) from a different study evidently showed that mean dust concentrations decreased significantly with increased distance.

Studies by (Aloh, 2008; Draid, et al 2015) have confirmed a positive relationship between respirable dust released from quarry activities and an increase rate of respiratory effects within quarry workers and surrounding community members. Fulekar (2008) confirmed differing negative effects of respirable dust released from quarry activities with age and distance from the mine.

2.3 Respirable dust exposure limits

Occupational Exposure Limits (OELs) are vital in the protection of dust exposed employees as they form part of legal standards (Miller, et al., 2005). According to the Lung Institute of Western Australia (2007) OELs are tools used in employee health risk assessments as they assist in determining the acceptability of different exposure scenarios. Thus, exposure limits above the required standard, remedial action is to be instituted.

2.3.1 Respirable crystalline silica exposure limits

The Occupational Safety and Health Administration (OSHA) published its new rule, a specific health standard for crystalline silica, which took effect on 23 June 2016 (Epstein, 2018). The rule established a permissible exposure limit (PEL) of 0.05 mg/m3, 8-hour total weight average (TWA) (50 µg/m3, 8-hour TWA), as well as an Action Level (a defined concentration level that necessitates certain required actions) of 0.025 mg/m3, 8-hour TWA (25 µg/m3, 8-hour TWA) regardless of the percentage and form of crystalline silica (Momyer, 2016). If workers are exposed to crystalline silica above the PEL, they must be protected through engineering controls such as using water to control dust generated by a work process or respirators provided by the employer. Since the PEL is measured as an eight-hour TWA, a worker can be exposed to levels above the PEL periodically during the work day, provided that his or her average exposure over eight-hours does not exceed the 50 µg/m3. This approach provides a consistent exposure limit for comparison; it also lowers the exposure limit significantly and regulates the actions required by employers. The NIOSH recommended exposure limit (REL) is 0.05 ppm (50 µg/m^3) for a 10-hour time-weighted exposure which would be adjusted to 15 µg/m3 for a 24-hour exposure (Szymendera, 2016). The new OSHA crystalline silica PEL will essentially match the NIOSH recommendation, although it will be measured as an average over an eight-hour day. OSHA 8-hour TWA limit of 15 mg/m^3 measures the total particulate, and retains the 5-mg/m^{3}limit for respirable particulates (Szymendera, 2016). These limits are aimed at safeguarding workers from safety and health risks which are connected to excessive exposure dust.

2.4 Lung function loss and dust exposure in quarry workers

The quarry industry in Namibia is one of the largest industries, and its workers are routinely exposed to respirable dust throughout various stages in the quarrying process. In Namibia, like many other developing nations, rock quarries utilize a great deal of manual labour with minimal personal protective equipment, and rarely is respiratory protection utilized. It has been established that occupational exposure to environments with high dust levels increase the risk of inhaling particles that could have negative respiratory effects (Draid et al., 2015). This has the potential to lead to lung damage from exposure to the aerosolized dust, particularly in the hot desert environment found within Namibia. While the health impacts to workers within the quarry industry have been studied in many different countries, it has been relatively unexplored in Namibia.

Draid et al. (2015) further argue that the occupational exposure to quarry dust may cause a number of health effects, including but not limited to the onset of acute or chronic respiratory diseases and respiratory functional deficits. Lung function impairment is one of the most common occupational respiratory problems associated with occupational dust exposures. A number of studies have evaluated the impact of dust on lung function, but most of these studies were conducted without considering the duration of the exposure and none of these studies has been performed in Namibia. Further clues may lie in the pattern of lung function deficit associated with dust exposure. There is some indication that the loss of Forced Vital Capacity (FVC) relative to forced expiratory volume measured at one second (FEV1) is greater from dust than from smoking. Dust exposure has been determined to result in a number of negative health impacts (Fulekar, 2008).

Momyer (2016) assessed the impact of the mining environment on respiratory functions. The results demonstrated that surface (quarry) workers had a slightly increased loss in predicted FVC and FEV I percentages. Sumana et al. (2016) measured cement production workers' lung function from 2007-2012 and witnessed a decrease in lung function for more than half of the workers over time due to constantly increased exposure to cement dust.

Ugbogu, Ohakwe and Foltescu (2009) allude to evidence of lung function obstruction or restriction measured by the FEV_1/FVC ratio emanating from tobacco smoking. Thus, there was an established link between smoking and low FEV_1/FVC ratios. Sufiyan and Ogunleye (2013) add that both FVC and FEV1 are decreased by smoking. This implies that smoking lowers lung volume resulting in airflow obstruction or restriction. Suhr, Bang and Moe (2007) predicted an annual excess decline of 0.84 % FEV_1. This explains that in 20 years more than 400 ml in lung capacity would have been lost. In light of this background, the Namibian government and quarry mining companies need to come up with measures that reduce the amount of dust generated during mining, improve the capture of dust emitted from the drill holes, and enhance protection offered by enclosed cabs on surface equipment.

2.5 Impacts of respirable dust on human respiratory health

NIOSH (2002) states that more than 23 million workers in China, 10 million in India, over 3 million workers in Europe and 1.7 million in the United States of America are exposed to crystalline silica. WHO (2007) estimates that approximately 125 million people the world-over are being exposed to asbestos dust and that more than 107 000 people die each year from asbestos-related lung cancer, mesothelioma and asbestosis resulting from exposure at work. One in every three deaths from occupational cancer is estimated to be caused by asbestos. Additionally, it is estimated that several thousand deaths annually can be attributed to exposure to asbestos in the surrounding communities. Respirable dust results in adverse health effects that range from minor impairment to irreversible diseases and life-threatening conditions. The health risk associated depends on the particle size, intensity of the exposure, the chemical nature of the particles and their interaction with human tissue, meteorological factors which include humidity, temperature, rain or wind and exposure time (duration). According to Bradshaw et al. (2010), exposure to RCS has many adverse health effects including silicosis, chronic obstructive pulmonary disease (COPD), lung cancer, pulmonary tuberculosis and some connective tissue disorders.

According to Bradshaw et al (2010) exposure to respirable dust by quarry workers leads to the following adverse respiratory effects; silicosis, asthma, inflammation of lungs and fibrosis Overexposure to respirable dust may lead to diffuse pulmonary fibrosis with increasing dyspnoea. Severe cases may progress even after cessation of exposure. This disease is often complicated with occupational asthma. Dusts cause allergic response actions, either in the respiratory system such as asthma-like, or skin such as rashes and eruptions. Asthma has an ongoing effect occurring for weeks to years after exposure. The sensitizer induces certain specific cellular changes so that after a period of latency, further contact results in an acute allergic reaction (Rushton, 2007). Emphysema occurs as more and more of the walls between air sacs get destroyed and sacs break up leaving fewer larger sacs. These bigger sacs have less surface area for the exchange of oxygen and carbon dioxide than the tiny ones. Poor exchange of oxygen and carbon dioxide causes shortness of breath. Chronic bronchitis happens when the airways are inflamed and thickened. More of the cells in the airways make mucus, so the result is a habitual cough and difficult breathing (Reindel & Goldsmith, 2011).

A study by Nwibo et al. (2012) investigating pulmonary problems amongst quarry workers discovered that quarry workers had developed several respiratory ailments which consisted of shortness in breath, wheezing, coughing and chest pains. Data from the same study suggested that cough, wheezing and shortness of breath were quite prominent. Moreover, data from the study suggests that continued exposure to dust from quarrying activities bears the capability of increased susceptibility to respiratory health effects as well as reduced lung functions due tobacco or cigarette smoking.

Ugbogu, Ohakwe, & Foltescu (2009) confirmed close to 85% incidences of respiratory health effects (signalled by respiratory symptoms) amongst quarry manual stone workers. Momyer (2016) found out that respiratory health effects due to dust exposure were aggravated by non-usage of personal protective equipment by quarry workers as their employers were unable to provide such. Nwibo et al. (2012) discovered that approximately 98.3% of quarry workers did not use personal protection or failed to abide by expected safety measures. A study by Olusegun, Adeniyi and Adeola (2009) in Abeokuta Ogun State, Nigeria investigated the health effects of granite quarrying on employees and surrounding community members and found out negative impacts on the study participants.

Study findings by Shadab, Agrawal, Ahmad and Aslam (2013) showed that respiratory symptoms such as phlegm, coughing and wheezing were commonly found among sweepers (cleaners). This can be attributed by the fact that cleaners were more exposed to minerals and organic dust from cleaning and they lacked sound respiratory protection equipment. Bradshaw et al. (2010) concur that wheezing and coughing had five to six times of incidence among the exposed compared to the non-exposed.

Workers may be at risk of silicosis from exposure to silica dust when high-velocity impact shatters the sand into smaller, respirable (< 0.5 to 5.0 µm in diameter) dust particles. Silicosis is a fibrotic lung disease resulting from overexposure to crystalline silica dust often described as simple or complicated silicosis. Complicated silicosis is linked with the development of more significant clinical features, including breathlessness and respiratory disability, whilst simple silicosis is not apparent to clinical problems (Ugbogu et al., 2009). Silicosis occurs with higher exposure concentrations of 200– 500 µg/m3 over prolonged periods (Esswein et al., 2012).

Varying types of silicosis exist and range from the most severe (acute silicosis) to the most common (chronic silicosis) (Fulekar, 2008). In acute silicosis, the worker is exposed to extremely high silica concentrations over a relatively short period of 6 months to 2 years. Chronic silicosis is the most common form of silicosis and the fibrotic changes in the lungs are seen after ten to thirty years of exposure to dust that contains 18-30% crystalline silica (Beckett, 1997). Acute and accelerated silicosis usually occur where the worker is exposed to high concentrations of fine respirable crystalline silica particles exceeding 50 µg/m3.

According to Epstein (2018) the duration of exposure to crystalline silica particles plays a crucial role in the development of the disease. Longer exposure periods such as in chronic silicosis result in decreases in lung functions denoted by lower FEV1, FEC and PEFR percentages. This suggests lung function obstruction or restriction. Silicosis can progress even after a person is no longer exposed to the dust, causing severe shortness of breath years later. The more years of exposure to dust, the greater the risk of the disease.

A study carried out by Suhr, Bang, and Moe (2007) in Norway compared COPD, silicosis and lung function occurrence, and reported a greater occurrence of respiratory anomalies as opposed to controls among slate workers. The increased occurrence of these respiratory disorders among quarry workers indicated early stages of lung obstruction and/or restrictiveness to workers who are exposed to long periods of respirable dust. The occurrence of silicosis amongst slate workers was between 1.9 and 6.5%, with seven workers being diagnosed.

The silica-related disease is a health disparities issue despite the improved protection for some workers. Silica dust related illnesses have a greater impact on quarry workers than on the general population. According to Reindel and Goldsmith (2011), communities around quarry mines showed greater incidence of silica-linked conditions, and lack the education, resources and power to demand effective protection. Public health, industry, and occupational medicine leaders need to provide greater collaboration with minority communities at risk so that dust control can become universal. Programmes should stress prevention and evaluation efforts to effectively target worker populations disproportionately exposed to silica at work, including minority and immigrant communities (Bradshaw et al., 2010).

The situation described above is not unique to the Namibian context considering the national statistical reports about quarry workers who acquired occupational respiratory diseases due to respirable dust exposure.

2.6 Workers' awareness of the health risks posed by exposure to quarry respirable dust

Bradshaw et al. (2010) mention that many workers are unaware of potential hazards present in their working environment, thus making them more vulnerable to occupational hazards. Workers complain that using PPE can slow down their efficiency as well as having an uncomfortable feeling.
Results of a study by Aloh (2008) on an awareness assessment showed a high level of ignorance of quarry workers and their employer. Little protective measures were observed on workers save washing of hands and changing into clean clothes before leaving for home. The use of protective clothing and equipment during working hours was very low - almost non-existed. Most workers did not receive any form of training with respect to their job. In the same study, clinical history revealed that dust inhalation was the commonest source of health hazards (81.6%).

Sufiyan and Ogunleye (2013) found out that most of the respondents (89.2%) used at least one safety protective device at work in astudy done in Sabon-Gari Local Government Area of Nigeria. The most commonly used devices among the respondents were hand/finger gloves used by 83.3% and eye goggles used by 77.3%. Only 10.6% of the respondents used facemasks, while 9.1% used safety helmets and safety boots. As little as 4.5% used earplugs. It is worth knowing that none of the respondents used overalls as a safety protective device. A significant proportion of the respondents (80.3%) used these devices always, while 10.6% of them only use the devices whenever they are available at the workplace. In addition, 6.1% of the respondents use the devices only when they feel like using them, while 3.0% use them every 2 days. In conclusion, the majority of the quarry workers in Sabon-Gari Local Government Area know that their job exposes them to health hazards. They have a high level of awareness on safety protective devices and the use several of the devices, though with varying levels of compliance.

The purpose of this study was to assess the dust exposure and risk of chronic respiratory diseases among stone quarry workers in Namibia.

CHAPTER THREE: STUDY METHODOLOGY

3.1. Research design

The research adopted a quantitative analytic approach which followed a cross-sectional descriptive study. The quantitative aspect compared dust effects on the exposed and non-exposed group, while the analytical aspect measured lung functioning of both the quarry workers and community members so as to assess the risk associated with dust exposure.

3.2. Study site

There are approximately 20 quarry mines in Namibia that are distributed in regions of Kunene, Khomas, Oshikoto and Erongo. Erongo region tops the list with more than 8 quarry mines. The study area is situated on the outskirts of Karibib town in the Erongo region. Karibib has an estimated population of 16807 inhabitants as calculated using the growth rate of 3.4% per year, and Karibib owns 97 square kilometres of town land (Namibia Statistic Agency, 2011). For ethical reasons, the name of the study sites in this research are referred to as Quarry A, B, C, and D.

3.3. Study population

According to the Ministry Mines and Energy (2017), about 17,000 people were employed by the mining and quarry sector in 2017, of which 9,643 were permanently employed, 889 temporarily employed and 6,373 were contractors. In this study, all quarry workers, foreign contractors and surrounding community members from all 4 sites who met the inclusion criteria were invited to participate in the study based on their availability and willingness to participate.

3.4. Sampling frame

The sampling frame comprised of all quarry workers and the population that met the inclusion criteria. The four (4) mining quarry sites and community members from Karibib were sampled. The sample included both exposed quarry workers and non-exposed community members.

3.5 Sample size determination

The sample size was calculated based on the country prevalence rate (4.1%) for respiratory diseases for 2014 (WHO, 2014). Sample size calculation formula: n = 1.952 P (100-P)/E2, where n = sample size, P = proportion of the population with the desired factor, E = acceptable margin of error (5%). n =1.952x4.1 (100-4.1.)/52= 60 (59.8), plus 10% [6*7=42] of each of the following covariates (age, gender, smoking, history of TB, family history of respiratory related diseases, occupational history, other environmental factors) and 10 % for refusal. The sample size was 113 participants, each for quarry workers and community members. The study sampled 120 quarry workers and community members were a total of 113, all summing to 223 participants.

3.6 Sampling method

The study sampled 120 quarry workers using convenient sampling method from all 4 quarry sites and participated in self-administered questionnaires and lung function test. Convenient sampling was used because the target population was available at a certain time at the sites thereby making every subject available fit for participation. Random sampling was used to select a number of 113 participants from the community, with every 3rd household being selected on the basis of willingness to participate in the study. On average each site sampled 30 workers and 28 community members.

Typical purposive sampling was used to collect personal dust levels from 40 quarry workers because it enabled a comparison in the levels and amount of dust with different job categories. Personal dust levels were measured according to job categories so as to establish the job category with high, medium or low exposure levels.

Out of the 40 workers selected for personal dust sampling, 10 samples where purposely selected for silica analysis employing to the extreme or deviant style. Extreme or deviant purposive sampling enabled the researcher to further investigate outliers or participants that had shifted from normal established dust exposure level trend. Thus, participants with the highest dust exposure levels were referred for silica assessment.

3.7 Pilot study

A pilot study was conducted at one of the quarry sites (site F) which were not covered in the main study. The researcher approached and invited participants to participate in the study, and obtained their voluntary informed consent. A total of 10 participants demonstrated their consent by signing the consent form; some participants invited did not give consent and they were excluded from the study. The study procedures for data collection encountered some initial problems with the research instrument which had some offensive questions and some were repetitive and this did not go down well with the participants. In addition, the timing was inappropriate as most people preferred to be interviewed during lunch as the researcher had gone before lunch (around 11am). The processes of approaching and securing access to potential participants were initially rather frustrating due to the fact that some participants were not willing to participate and some did not want to disclose information during the interviews.

The pilot study provided a unique opportunity to improve the researcher's skills in using the questionnaire method in terms of approaching potential participants, selecting the interview environment and engaging in deep conversations. The offensive questions were rephrased to make them more friendly questions. The pilot study enabled the consideration of strategies to minimize these problems and ultimately, determined the success of data collection during the main study.

3.8 Data collection

Data was collected using the following techniques:

3.8.1 Questionnaire method

A total of 233 interviewer-administered questionnaires were issued to both quarry workers and community members. The questionnaires obtained data on participants' health, duration of shift, period of exposure, daily activities, previous work history, respiratory illness symptoms, and number of hospital visits. The questionnaire was adopted from Miller et al (2005).

3.8.2 Lung function assessments

The lung function assessments were conducted using Spiro Bank II, and performed in accordance with the American Thoracic Society [ATS] criterion. Lung function tests were conducted to detect abnormalities associated with respiratory disorders. The tests were performed with a graphic representation of the manoeuvre with both flow-volume and volume-time displayed. The primary signal measured in spirometry may be volume or flow. These measurements included forced vital capacity (FVC), which is the volume delivered during expiration made as forcefully and completely as possible starting from full inspiration, and the forced expiratory volume (FEV) in one second, which is the volume delivered in the first second of an FVC manoeuvre. Other spirometric variables derived from the FVC manoeuvre were also addressed (Miller et al., 2005). A 3L calibration syringe was used to calibrate instrument volume at the beginning of each shift and every four hours. A minimum of 3 manoeuvres was performed per participant and the best trial was chosen on ATS criterial.

Lung function tests were done to 120 workers and 113 community members by a qualified technician who was hired by the researcher. Results were presented in percentages of the predicted normal values. Comparisons were done between the reference value and an individual's measured value. FVC and FEV1 results greater or equal to 80% were regarded as normal while below 80% was regarded as abnormal (<79% - mild, < 69% - moderate and < 60% - severe). FEV1/FVC ratios greater or equal to 70% were considered normal whereas below 70% were abnormal (< 69% - Mild, < 59% - moderate, < 50% - severe)

3.8.3 Personal dust sampling

A Gil Air RC Dust Sampling Pump was used to conduct personal dust sampling by means of the NIOSH Method 0600, using 37mm PVC filter operating at 2.2 volume, mean temperature of 25-30°C and relative humidity of 70-80%. A total of 40 quarry workers across all job categories were sampled for respirable dust assessment with every fourth filter selected for silica analysis. Silica samples were sent to South Africa for further analysis. The dust sampling was conducted on an eight-hour full-shift (thus from 07h 00 to 15h 00) thus observing the Time Weighted Average (TWA) with selected workers wearing the pump at their work places.

Workers from each work category were randomly selected for personal dust sampling and an average of 3 samples being collected per job description. Results were extrapolated by work category in each factory. Because the country does not have an occupational exposure limits for carbon-containing material, dust exposure results were compared to the exposure limit set by the United States Occupational Safety and Health Administration (OSHA). Before use, the pumps were calibrated using a standard calibration pressure instrument. The pump flowrates were also constantly monitored.

3.9 Data analysis and interpretation

The collected data was analysed using Statistical Package for Social Sciences (SPSSS) version 22, after it was checked and cleaned. The Kolmogorov-Smirnov as well the Shapiro-Wilk tests showed that the data were non-normally distributed ($p<0.05$) and therefore non-parametric statistical methods were used in the subsequent bivariate and multivariate analysis. The chi-square test of association was used to compare the prevalence of the assessed health outcomes according to the quarry sites, years worked at the site, job descriptions and dust exposure levels. The chi-square test of association was also used to compare the prevalence of respiratory symptoms according to exposure to quarry work (i.e. between the quarry workers versus a sample of community members not involved in quarry work). In the case of variables measured on a continuous scale, the Kruskal-Wallis test as well as Spearman's Rho correlational analysis were used to examine for relationships.

Logistic regression modelling was run to identify risk factors for respiratory symptoms. The process involved an initial run of univariable models to identify variables suitable for inclusion in the subsequent multivariable model. A less strict cut off p-value of 0.25 was set for the selection of variables to include the final model. This was done to avoid excluding variables that are known to have an effect in relation to respiratory diseases. The logistic regression models accounted for confounding variables such as age and gender, among others.

Dust exposure levels among the quarry workers were classified into three levels of low, medium and higher exposure. This was done by first calculating mean dust levels from the collected ppersonal respirable dust levels and then extrapolating these mean dust levels to all similar exposure groups (SEG) such that all the quarry workers at all the sites in the study were allocated a mean dust level. Percentile groups on mean dust levels were then computed in SPSS to create three mean dust exposure levels as shown below.

Table 3.1: Mean dust exposure levels

Exposure level	**Mean dust level (mg/m³)**	
	Minimum	**Maximum**
Low	0.13	0.55
Medium	0.56	1.03
High	1.04	2.19

In addition to the above mean dust exposure levels, cumulative dust exposure levels were also allocated to the quarry workers in the study. Cumulative dust exposure for each worker was calculated by multiplying the mean dust level per position by the number of years in the position. Percentile groups on cumulative dust levels were then computed in SPSS to create three cumulative dust exposure levels as shown below.

Table 3.2: Cumulative dust exposure levels

Exposure level	Cumulative dust level (mg/m³)	
	Minimum	**Maximum**
Low	0.83	33.33
Medium	33.34	67.08
High	67.09	100.00

Unlike the respirable dust levels which were categorised into low, medium and high exposure as above, silica exposure was not categorised but was analysed as continuous data.

3.10 Ethical considerations

Permission to conduct research was obtained from the Namibia' University of Science and Technology and the Ministry of Health and Social Services (reference Number 17/3/3ss). A signed written consent form (shown in Appendices) was obtained from the participants after detailing the purpose of the study with provisions given to them to withdraw from the study at any time. The researcher protected the participants from harm by protecting their anonymity and confidentiality, avoiding deceptive practices and providing participants with the right to withdraw from the research at any time. Privacy and anonymity were ensured by not putting any identifying information such as names on research instruments; instead of numerical and alphabetical coding was used. All data were treated with strict confidentiality, and only the researcher knew the origin of the data and data was stored in a computer with a password only known to the researcher.

CHAPTER FOUR: RESULTS

The following articles are prepared in accordance with the Occupational Health Southern Africa journal guidelines

4.1. Article 1 Assessment of the Prevalence of respiratory symptoms among quarry workers and community members, Karibib, Namibia 2018.

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4.1.1. Abstract

This study aimed at assessing the prevalence of respiratory symptoms among quarry workers and community members in Karibib town in the Erongo region. The study adopted a quantitative observational and analytic approach following a cross-sectional descriptive study. The study population included fulltime quarry mine workers drawn from the 4 quarry mines and non-exposed group (community members) all from Karibib town in Erongo region.

The study found out varying dust levels across all four sites, with Site A having the highest exposure and Site B having the least exposure. However, the highest dust exposure limit at Site A was below the international recommended limits. Variations in dust exposure within sites were as a result of differences in dust generation from various worksites where designated job categories are placed. Within all the sites, the Excavation Job Category was the highly exposed while Wire Saw Category was the least exposed. This can be attributed to the fact that Wire Saw, of all the sites, used water which reduced the amount of dust generated during quarrying. There was a higher level of dust exposure to quarry workers (0.85 mg/m^3) as compared to community members (0.62 mg/m^3). Community members had limited exposure time to dust as compared to quarry workers. Finally, the study did not find a link between respiratory diseases and dust exposure which could be that the dust levels at the research sites are low – which would be a good thing. It however, could also be due to the small sample size (i.e. n=40.

A key recommendation based on our findings is the need to monitor the health states of workers on a regular basis by performing occupational medical examinations (pre, ongoing and post-tests) as the study found that there were no medical examination records at any of the studied sites. Environmental management systems which include a dust management plan should be employed at the quarries in order to mitigate dust generation.

4.1.2. Introduction

Workers in the quarry mining sector have been exposed to occupational respiratory diseases and conditions. Dust exposure has been a major predisposing factor contributing to respiratory diseases/conditions among quarry workers. Health surveillance on mining premises revealed respiratory symptoms as the main indicator of respirable dust exposure. Momyer (2016) signifies a strong relationship between dust exposure and an increase in respiratory symptoms. Respiratory symptoms include a persistent cough and phlegm production, breathlessness and wheezing which relate significantly with individuals' cumulative exposure to respirable mixed with dust.

Esswein et al. (2012) found out that about 11 percent of asthma and 13 percent of all chronic obstructive pulmonary diseases (COPD) have been contributed by occupational dust exposure within the mining industry. Esswein et al. (2012) report that about 318,000 annual deaths and about 3.7 million DALYs were COPD work-related, asthma posed an occupational risk burden of about 38,000 deaths and about 1.6 million DALYs, mainly affecting 26-37 years of age. These aforementioned occupational risks posed a significant loss of time from work as well as a high economic loss.

Quarrying activities generate a significant amount of dust that affects health. Stone quarry dust comprises of both fine and coarse particulate matters that have varying adverse effects on the body, particularly on the respiratory organs. The multistage processes of stone quarry such as drilling, rock extraction, crushing and sorting produce dust which poses risk to the respiratory system (Nwibo et al., 2012).

Decreased lung function, increased hospital admissions, mortality from cardiopulmonary, death and cardiovascular symptoms are mainly associated with respirable dust penetrating deep into the lungs and entering the blood circulatory system (Millers et al., 2013). Exposure to the high amounts of respirable dust above TWA (Time Weighted Average) can lead to death and cardiovascular symptoms since it can penetrate deep into the lungs and then enter the blood circulatory system (Naidoo et al., 2006). Exposure to dust such as crystalline silica, mainly at the point sources in aggregate quarries increases the risk of diseases to workers. Epidemiological evidence is therefore required to unravel this complexity in the Namibian quarrying industry.

4.1.3. Study Method

4.1.3.1 Research Design

The research adopted a quantitative analytic approach which followed a cross-sectional descriptive study. The quantitative aspect compared dust effects on the exposed and non-exposed group while the analytical aspect measured lung functioning of both the quarry workers and community members so as to assess the risk associated with dust exposure.

4.1.3.2 Study Site

There are approximately 20 quarry mines in Namibia, distributed in regions of Kunene, Khomas, Oshikoto and Erongo. Erongo region tops the list with more than 8 quarry mines. The study area is situated on the out skirts of Karibib town in the Erongo region. Karibib has an estimated population of 16807 inhabitants as calculated using the growth rate of 3.4% per year, and it owns 97 square kilometres of town land Namibia Statistics Agency (2011). For ethical reasons, the name of the study sites in this research was referred to as Quarry A, B, C, and D.

4.1.3.3. Study Population

According to the Ministry of Mines and Energy (2018), about 17,000 people were employed by the mining and quarry sector in 2017, of which 9,643 were permanently employed, 889 temporarily employed and 6,373 were contractors. In this study, all quarry workers, foreign contractors and surrounding community members from all 4 sites who met the inclusion criteria were invited to participate in the study based on their availability and willingness to participate.

4.1.3.4. Sampling Frame

The sampling frame comprised of all quarry workers and a population that met the inclusion criteria. The four (4) mining quarry sites and community members from Karibib were sampled. The sample included both exposed quarry workers and non-exposed community members.

4.1.3.4.1 Sample size determination

The sample size was calculated based on the country prevalence rate (4.1%) for respiratory diseases for 2014 (WHO, 2014). The sample size calculation formula was: n = 1.95^2 P (100-P)/E^2, where **n** = sample size, **P** = proportion of the population with the desired factor, E = Acceptable margin of error (5%). n =1.95^2x4.1 (100-4.1.)/5^2= 60 (59.8), plus 10% [6*7=42] of each of the following covariates (age, gender, smoking, history of TB, family history of respiratory-related diseases, occupational history, other environmental factors) and 10% for refusal. The sample size was 113 participants each for quarry workers and community members. The study sampled 120 quarry workers and community members were 113, all summing to 223 participants.

4.1.3.4.2 Sampling method

The study sampled 120 quarry workers using convenient sampling method from all 4 quarry sites and participated in self-administered questionnaires and lung function test. Convenient sampling was used because the target population was available at a certain time at the sites thereby making every subject available fit for participation. Random sampling was used to select a number of 113 participants from the community, with every 3rd household being selected on the basis of willingness to participate in the study. On average each site sampled 30 workers and 28 community members.

Typical purposive sampling was used to collect personal dust levels from 40 quarry workers because it enabled a comparison in the levels and amount of dust with different job categories. Personal dust levels were measured according to job categories so as to establish the job category with high, medium or low exposure levels.

Out of the 40 workers selected for personal dust sampling, 10 samples where purposely selected for silica analysis employing to the extreme or deviant style. Extreme or deviant purposive sampling enabled the researcher to further investigate outliers or participants that had shifted from normal established dust exposure level trend. Thus, participants with the highest dust exposure levels were referred for silica assessment.

4.1.3.4.3 Pilot study

A pilot study was conducted at one of the quarry sites (site F) which were not covered in the main study. The researcher approached and invited participants to participate in the study, and obtained their voluntary informed consent. A total of 10 participants demonstrated their consent by signing the consent form; however, some participants invited did not give consent and they were excluded from the study. The study procedures for data collection encountered some initial problems with the research instrument which had some offensive questions and some of them were repetitive and this did not go down well with the participants. In addition, the timing was inappropriate as most people preferred to be interviewed during lunch as the researcher had gone before lunch (around 11am). The processes of approaching and securing access to potential participants were initially rather frustrating due to the fact that some participants were not willing to participate and some did not want to disclose information during the interviews.

The pilot study provided a unique opportunity to improve the researcher's skills in using the questionnaire method in terms of approaching potential participants, selecting the interview environment and engaging in deep conversation. The offensive questions were rephrased to make them more friendly questions. The pilot study enabled the consideration of strategies to minimize these problems and ultimately, determined the success of data collection during the main study.

4.1.3.5 Data collection

4.1.3.6

Data were collected using the following techniques:

4.1.3.5.1 Questionnaire method

A total of 233 interviewer-administered questionnaires were issued to both quarry workers and community members. The questionnaires obtained data on participants' health, duration of the shift, a period of exposure, daily activities, previous work history, respiratory illness symptoms, and a number of hospital visits. The questionnaire was adopted from Miller et al (2005).

4.1.3.5.2 Lung function assessments

The lung function assessments were conducted using Spiro Bank II, and performed in accordance with the American Thoracic Society [ATS] criterion. Lung function tests were conducted to detect abnormalities associated with respiratory disorders. The tests were performed with a graphic representation of the manoeuvre with both flow-volume and volume-time displayed. The primary signal measured in the spirometry may be volume or flow. These measurements included forced vital capacity (FVC), which is the volume delivered during expiration made as forcefully and completely as possible starting from full inspiration, and the forced expiratory volume (FEV) in one second, which is the volume delivered in the first second of an FVC manoeuvre. Other spirometric variables derived from the FVC manoeuvre were also addressed (Miller et al, 2005). A 3L calibration syringe was used to calibrate the instrument's volume at the beginning of each shift and every four hours. A minimum of 3 manoeuvres was performed per participant and the best trial was chosen on the ATS criterial.

Lung function tests were done to 120 workers and 113 community members by a qualified technician who was hired by the researcher. Results were presented in percentages of the predicted normal values. Comparisons were done between the reference value and an individual's measured value. FVC and FEV1 results greater or equal to 80% were regarded as normal while below 80% as abnormal (<79% - Mild, < 69% - Moderate and < 60% - Severe). FEV1/FVC ratios greater or equal to 70% were considered normal whereas below 70% were abnormal (< 69% - Mild, < 59% - Moderate, < 50% - Severe).

4.1.3.5.3 Personal dust sampling

A Gil Air RC Dust Sampling Pump was used to conduct personal dust sampling by means of the NIOSH Method 0600, using 37mm PVC filter operating at 2.2 volume, mean temperature of 25-30°C and relative humidity of 70-80%. A total of 40 quarry workers across all job categories were sampled for respirable dust assessment with every fourth filter selected for silica analysis. Silica samples were sent to South Africa for further analysis. The dust sampling was conducted on an eight-hour full-shift (thus from 07h 00 to 15h 00) thus observing the Time Weighted Average (TWA) with selected workers wearing the pump at their work places.

Workers from each work category were randomly selected for personal dust sampling and an average of 3 samples was collected per job description. Results were extrapolated by work category in each factory. Because the country does not have occupational exposure limits for carbon-containing material, dust exposure results were compared to the exposure limit set by the United States Occupational Safety and Health Administration (OSHA). Before use, the pumps were calibrated using a standard calibration pressure instrument. The pump flowrates were also constantly monitored.

4.1.3.6 Data analysis and interpretation

The collected data were analysed using Statistical Package for Social Sciences (SPSSS) version 22, after it was checked and cleaned. The Kolmogorov-Smirnov as well as the Shapiro-Wilk tests showed that the data were non-normally distributed ($p<0.05$) and therefore non-parametric statistical methods were used in the subsequent bivariate and multivariate analysis. The chi-square test of association was used to compare the prevalence of the assessed health outcomes according to the quarry sites, years worked at the site, job descriptions and dust exposure levels. The chi-square test of association was also used to compare the prevalence of respiratory symptoms according to exposure to quarry work (i.e. between the quarry workers versus a sample of community members not involved in quarry work). In the case of variables measured on a continuous scale, the Kruskal-Wallis test as well as Spearman's rho correlational analysis were used to examine for relationships.

Logistic regression modelling was run to identify risk factors for respiratory symptoms. The process involved an initial run of univariable models to identify variables suitable for inclusion in the subsequent multivariable model. A less strict cut off p-value of 0.25 was set for the selection of variables to include the final model. This was done to avoid excluding variables that are known to have an effect in relation to respiratory diseases. The logistic regression models accounted for confounding variables such as age and gender, among others.

Dust exposure levels among the quarry workers were classified into three levels of low, medium and higher exposure. This was done by first calculating mean dust levels from the collected ppersonal respirable dust levels and then extrapolating these mean dust levels to all similar exposure groups (SEG) such that all the quarry workers at all the sites in the study were allocated a mean dust level. Percentile groups on mean dust levels were then computed in SPSS to create three mean dust exposure levels which are as follows; Low (0.13-0.55 mg/m^3); Medium (0.56-1.03 mg/m^3) and High (1.04-2.19 mg/m^3)

In addition to the above mean dust exposure levels, cumulative dust exposure levels were also allocated to the quarry workers in the study. Cumulative dust exposure for each worker was calculated by multiplying the mean dust level per position by the number of years in the position. Percentile groups on cumulative dust levels were then computed in SPSS to create three cumulative dust exposure levels which are as follows; Low (0.83-33.33 mg/m^3); Medium (33.34-67.08 mg/m^3) and High (67.09-100 mg/m^3)

Unlike the respirable dust levels which were categorised into low, medium and high exposure as above, silica exposure was not categorised and was analysed as continuous data.

4.1.3.7 Ethical considerations

Permission to conduct research was obtained from the Namibia University of Science and Technology and the Ministry of Health and Social Services (reference Number 17/3/3ss). A signed written consent form was obtained from the participants after detailing the purpose of the study with provisions given to them to withdraw from the study at any time. The researcher protected the participants from harm by protecting their anonymity and confidentiality, avoiding deceptive practices and providing participants with the right to withdraw from the research at any time. Privacy and anonymity were ensured by not putting any identifying information such as names on the research instruments, instead of numerical and alphabetical coding was used. All data were treated with strict confidentiality, and only the researcher knew the origin of the data and data were stored in a computer with a password only known to the researcher.

4.1.4. Results

4.1.4.1. Demographic information

The socio-demographic profiles of the study participants are presented in Table 4.1 and of the 120 quarry workers, 114 (95%) were male and only 6 (5%) were female. In contrast, of the 96 non-exposed respondents, 79% were female and 21% male. The mean age, height, weight and BMI for the quarry workers were all highly comparable to corresponding measures in the control group.

Table 4.1: Socio-demographic information of study participants

Variables	Frequency and percentage (%)			
	Quarry workers (n=120)		Non-exposed(n=96)	
Gender				
Male	114	(95)	20	(21)
Female	6	(5)	76	(79)
Educational attainment				
No education	19	(16)	-	-
Primary school	72	(60)	-	-
Secondary school	29	(24)	-	-
Job specification				
Cleaner	12	(10)	-	-
Drilling	18	(15)	-	-
Excavator	21	(18)	-	-
Loading	31	(26)	-	-
Supervisor	16	(13)	-	-
Wire Saw	22	(18)	-	-
	Mean and standard deviation (SD)			
Age (years)	32.7	(7.4)	32.5	(10.0)
Work experience (years)	5.7	(2.6)	3.1	(2.1)
Height (cm)	169.6	(6.4)	168.1	(6.8)
Weight (kg)	67.1	(14.3)	68.3	(15.0)
BMI	23.4	(5.2)	24.2	(5.4)

Table 4.2: Job specification of non-exposed study participants (n=96)

	Frequency and percentage (%)	
Administrator	5	(5)
Bar Tender	8	(8)
Cashier	12	(13)
Cleaner	2	(2)
Hairdresser	10	(10)
House wife	6	(6)
Other	6	(6)
Soldier	16	(17)
Student	4	(4)
Teacher	7	(7)
Unemployed	8	(8)
Vendor	12	(13)

4.1.4.1. Environmental factors

The results in Table 4.3 show that the majority of quarry workers (63%) used wood for cooking, followed by gas at 32%. Wood was also commonly used among the community members (41%) although usage of electricity was marginally higher (43%). Altogether, only 4% of the quarry workers used electricity for cooking and this was significantly lower when compared to the control group (p=0.01).

Table 4.3: Fuel used for cooking by quarry workers and non-exposed participants

Variables	Frequency and percentage (%)							
	Electric		Gas		Paraffin		Wood	
Quarry site								
Site A (n=27)	1	(4)	9	(33)	1	(4)	16	(59)
Site B (n=30)	0	(0)	9	(30)	0	(0)	21	(70)
Site C (n=30)	1	(3)	11	(37)	0	(0)	18	(60)
Site D (n=33)	3	(9)	9	(27)	0	(0)	21	(64)
Job specification								
Cleaner (n=12)	0	(0)	5	(42)	0	(0)	7	(58)
Drilling (n=18)	1	(6)	8	(44)	0	(0)	9	(50)
Excavator (n=21)	0	(0)	4	(19)	1	(5)	16	(76)
Loading (n=31)	0	(0)	8	(26)	0	(0)	23	(74)
Supervisor (n=16)	0	(0)	5	(31)	0	(0)	11	(69)
Wire Saw (n=22)	4	(18)	8	(36)	0	(0)	10	(45)
Quarrying vs Non-exposed								
Quarry workers (n=120)	**5**	**(4)***	38	(32)	1	(1)	76	(63)
Non-exposed (n=96)	**41**	**(43)***	16	(17)	0	(0)	39	(41)

***p<0.05**

Although the results varied by site and job specification, the smoking history patterns presented in Table 4.4 show that in total, 78% of the quarry workers had never smoked compared to 95% among community members. There were therefore significantly more respondents with a smoking history among quarry workers compared to community members (p=0.01). However, this was due to the male and female skews in the respective samples and, controlling for gender, the difference in smoking patterns was not statistically significant between the quarry workers and the community. The percentage of non-smokers was lower at Site B (60%) compared to Site A (78%), Site C (87%) and Site D (88%) and this difference was statistically significant (p=0.01).

Table 4.4: Smoking history among quarry workers and non-exposed participants

Variables	Frequency and percentage (%)		
	Never smoked	Up to 5 years	6 – 10 years
Quarry site			
Site A (n=27)	21 (78)	3 (11)	3 (11)
Site B (n=30)	**18 (60) ***	11 (37)	1 (3)
Site C (n=30)	26 (87)	1 (3)	3 (10)
Site D (n=33)	29 (88)	1 (3)	3 (9)
Job specification			
Cleaner (n=12)	10 (83)	1 (8)	1 (8)
Drilling (n=18)	13 (72)	4 (22)	1 (6)
Excavator (n=21)	17 (81)	2 (10)	2 (10)
Loading (n=31)	26 (84)	1 (3)	4 (13)
Supervisor (n=16)	12 (75)	4 (25)	0 (0)
Wire Saw (n=22)	16 (73)	4 (18)	2 (9)
Quarrying vs Non-exposed			
Quarry workers (n=120)	**94 (78) ***	16 (13)	10 (8)
Non-exposed (n=96)	**91 (95) ***	4 (4)	1 (1)

***p<0.05**

The results pertaining to usage of a dust mask by the quarry workers are presented in Table 4.5 and they show that workers from Site C used the dust mask significantly less (80%) compared to the other three sites (p=0.01). A significantly lower percentage (86%) of quarry workers with 7-9 years' experience used a dust mask (p=0.03) but there were no significant differences in usage of the dust mask by job specification (p=0.54) or by level of education (p=0.35)

Table 4.5: Use of a dust mask among quarry workers

Variables	Frequency and percentage (%)	
Quarry site		
Site A (n=27)	27	(100)
Site B (n=30)	30	(100)
Site C (n=30)	**24**	**(80)***
Site D (n=33)	33	(100)
Job specification		
Cleaner (n=12)	11	(92)
Drilling (n=18)	17	(94)
Excavator (n=21)	21	(100)
Loading (n=31)	28	(90)
Supervisor (n=16)	15	(94)
Wire Saw (n=22)	22	(100)
Work experience		
1-3 years (n=25)	25	(100)
4-6 years (n=50)	49	(98)
7-9 years (n=36)	**31**	**(86)***
10 years or more (n=9)	9	(100)
Education		
No education (n=19)	18	(95)
Primary school (n=72)	67	(93)
Secondary school (n=29)	29	(100)

***p<0.05**

4.1.4.2. Dust exposure

Table 4.6 presents the percentages of quarry workers who fell into each of the dust exposure levels (i.e. low, medium and high dust exposure). The percentage of workers in the high mean dust exposure category was significantly high at Site A (59%) compared to the other three sites (p=0.01). The percentage of workers in the high mean dust exposure category was also significantly higher among excavators (81%) compared to the other job specifications (p=0.01).

Table 4.6: Dust exposure levels among quarry workers (n=120)

Variables	Frequency and percentage (%)					
	Low mean dust exposure		Medium mean dust exposure		High mean dust exposure	
Quarry site						
Site A (n=27)	8	(30)	3	(11)	**16**	**(59)** *
Site B (n=30)	10	(33)	16	(53)	4	(13)
Site C (n=30)	9	(30)	13	(43)	8	(27)
Site D (n=33)	14	(42)	7	(21)	12	(36)
Job specification						
Cleaner (n=12)	8	(67)	1	(8)	3	(25)
Drilling (n=18)	9	(50)	9	(50)	0	(0)
Excavator (n=21)	0	(0)	4	(19)	**17**	**(81)** *
Loading (n=31)	1	(3)	22	(71)	8	(26)
Supervisor (n=16)	5	(31)	3	(19)	8	(50)
Wire Saw (n=22)	18	(82)	0	(0)	4	(18)
Work experience						
1-3 years (n=25)	9	(36)	8	(32)	8	(32)
4-6 years (n=50)	18	(36)	14	(28)	18	(36)
7-9 years (n=36)	8	(22)	16	(44)	12	(33)
10 years or more (n=9)	6	(67)	1	(11)	2	(22)

$*p<0.05$

As shown in Table 4.7, the percentage of excavators in the high cumulative dust category was 71% and this was a significantly higher proportion compared to the other job specifications (p=0.01). None of the workers with 1-3 years' experience fell in the high cumulative dust category and this was a statistically significant difference compared to workers with more years of quarry work (p=0.01).

Table 4.7: Cumulative dust exposure levels among quarry workers (n=120)

Variables	**Frequency and percentage (%)**		
	Low cumulative dust exposure	**Medium cumulative dust exposure**	**High cumulative dust exposure**
Quarry site			
Site A (n=27)	6 (22)	12 (44)	9 (33)
Site B (n=30)	9 (30)	14 (47)	7 (23)
Site C (n=30)	11 (37)	9 (30)	10 (33)
Site D (n=33)	14 (42)	7 (21)	12 (36)
Job specification			
Cleaner (n=12)	4 (33)	6 (50)	2 (17)
Drilling (n=18)	7 (39)	7 (39)	4 (22)
Excavator (n=21)	1 (5)	5 (24)	**15 (71) ***
Loading (n=31)	6 (19)	15 (48)	10 (32)
Supervisor (n=16)	7 (44)	5 (31)	4 (25)
Wire Saw (n=22)	15 (68)	4 (18)	3 (14)
Work experience			
1-3 years (n=25)	19 (76)	6 (24)	**0 (0) ***
4-6 years (n=50)	16 (32)	21 (42)	13 (26)
7-9 years (n=36)	3 (8)	12 (33)	21 (58)
10 years or more (n=9)	2 (22)	3 (33)	4 (44)

***p<0.05**

4.1.4.3. Silica exposure

Table 4.8 presents the mean silica exposure levels among the quarry workers and results of the Kruskal-Wallis test showed that there were no significant differences in silica levels by quarry site (p=0.79), job types (p=0.41) or number of years in quarrying (p=1.00). Data on silica exposure was not collected from the non-exposed participants.

Table 4.8: Silica exposure among quarry workers (n=10)

	Crystalline Silica (mg/m^3) Mean and standard deviation (SD)	
Quarry site		
Site A (n=2)	0.0041	(0.0009)
Site B (n=2)	0.0049	(0.0007)
Site C (n-3)	0.0046	(0.0004)
Site D (n=3)	0.0066	(0.0038)
Job specification		
Cleaner (n=3)	0.0047	(0.0007)
Excavator (n=2)	0.0076	(0.0047)
Loading (n=3)	0.0048	(0.0001)
Supervisor (n=1)	0.0034	
Wire Saw (n=1)	0.0044	
Years in quarrying		
1-3 years (n=1)	0.0042	
4-6 years (n=6)	0.0044	(0.0005)
7-9 years (n=3)	0.0070	(0.0034)

***p<0.05**

4.1.4.4. Respiratory symptoms

The prevalence of respiratory symptoms among both the quarry workers and the non-exposed community members was a key element of the study and Table 4.9 presents frequencies and percentages of respondents who reported the listed symptoms. The most prevalent respiratory symptoms reported by the quarry workers was coughing (57%) and the corresponding percentage among the non-exposed group was lower at 14%. Episodes of phlegm and shortness of breath were reported by about a quarter of the quarry workers and, once again, the percentage of the non-exposed community members who reported these symptoms was much lower at only 1% to 3%. Shortness of breath was equally reported by quarry workers (23%) and the non-exposed (22%). Apart from a single case of asthma among the quarry workers, none of the study participants reported any of the other listed symptoms. Altogether, there were significantly more reports of coughing, phlegm in the morning, phlegm during the day or night and increased cough or phlegm among quarry workers than among the non-exposed (p=0.01).

Table 4.9: Prevalence of respiratory symptoms among quarry workers and non-exposed participants

Symptoms	Frequency and percentage (%)	
	Quarry workers (n=120)	Non-exposed (n=96)
Cough	68 (57)	**13 (14) ***
Phlegm in the morning	31 (26)	**3 (3) ***
Phlegm during day or night	31 (26)	**2 (2) ***
Increased cough or phlegm	26 (22)	**1 (1) ***
Shortness of breath	28 (23)	21 (22)
Chest wheezy or whistling	- -	- -
Attacks of bronchitis	- -	- -
Attacks of emphysema	- -	- -
Asthma	1 (1)	- -
Chest tuberculosis	- -	- -
Any other chest illness	- -	- -

***p<0.05**

About three quarters (76%) of the workers at Site D reported usual cough compared to approximately half at each of the other three sites as presented in Table 4.10. However, this difference was not statistically significant (p=0.08). Differences in prevalence of the other respiratory symptoms by quarry site were also not statistically significant.

Table 4.10: Prevalence of respiratory symptoms by quarry sites

Symptoms	Frequency and percentage (%)			
	Site A (n=27)	Site B (n=30)	Site C (n=30)	Site D (n=33)
Cough	14 (52)	14 (47)	15 (52)	25 (76)
Phlegm in the morning	6 (22)	11 (37)	5 (17)	9 (27)
Phlegm during day or night	6 (22)	11 (37)	5 (17)	9 (27)
Increased cough or phlegm	4 (15)	11 (37)	5 (17)	6 (18)
Shortness of breath	5 (19)	4 (13)	11 (37)	8 (24)
Asthma	1 (4)	- -	- -	- -

***p<0.05**

In relation to quarry worker job categories, the prevalence of coughing is shown in Table 4.11 below and it was significantly higher amongst cleaners (75%) compared to drilling (50%), excavators (48%), loaders (60%), supervisors (56%) and wire saw (59%) (p=0.02). Prevalence of phlegm was also significantly higher among cleaners (58%) in comparison to the other four job types (p=0.02).

Table 4.11: Prevalence of respiratory symptoms by quarry workers' job specifications

Symptoms	Frequency and percentage (%)					
	Cleaner (n=12)	**Drilling (n=18)**	**Excavator (n=21)**	**Loading (n=31)**	**Supervisor (n=16)**	**Wire Saw (n-22)**
Cough	**9 (75)***	9 (50)	10 (48)	18 (60)	9 (56)	13 (59)
Phlegm in the morning	**7 (58)***	2 (11)	4 (19)	7 (23)	2 (13)	9 (41)
Phlegm during day or night	**7 (58)***	2 (11)	4 (19)	7 (23)	2 (13)	9 (41)
Increased cough or phlegm	6 (50)	2 (11)	2 (10)	7 (23)	2 (13)	7 (32)
Shortness of breath	2 (17)	5 (28)	5 (24)	8 (26)	4 (25)	4 (18)
Asthma	- -	- -	1 (5)	- -	- -	- -

***p<0.05**

The prevalence of respiratory symptoms among the quarry workers was also compared according to the dust exposure levels as shown in Table 4.12. Although there were more reports of coughing (63%) among workers in the low dust exposure category compared to 49% in the medium and 58% in the high dust exposure level, these differences were not statistically significant (p=0.41). There were no significant associations between dust exposure levels and the prevalence of the other listed respiratory symptoms either.

Table 4.12: Prevalence of respiratory symptoms by dust exposure levels (n=120)

Symptoms	Low dust exposure (n=41)	Medium dust exposure (n=39)	High dust exposure (n=40)
Cough	26 (63)	19 (49)	23 (58)
Phlegm in the morning	13 (32)	8 (21)	10 (25)
Phlegm during day or night	13 (32)	8 (21)	10 (25)
Increased cough or phlegm	11 (27)	8 (21)	7 (18)
Shortness of breath	10 (24)	9 (23)	9 (23)
Asthma	- -	- -	1 (3)

***p<0.05**

Table 4.13 presents results on the prevalence of respiratory symptoms by number of years on exposure to quarry work. Cough was reported by 78% of workers with 10 years or more of exposure to quarrying and this was a higher percentage compared to 56% among workers with 7-9 years, 58% among workers with 4-6 years and 48% among those with 1-3 years. However, these differences were not statistically significant (p=0.48). Differences in the prevalence of the other listed respiratory symptoms based on the number of years working in quarrying were also not significant.

Table 4.13: Prevalence of respiratory symptoms by length of exposure (n=120)

Symptoms	**Frequency and percentage (%)**			
	1-3 years (n=25)	**4-6 years (n=50)**	**7-9 years (n=36)**	**10 years or more (n=9)**
Cough	12 (48)	29 (58)	20 (56)	7 (78)
Phlegm in the morning	5 (20)	13 (26)	12 (33)	1 (11)
Phlegm during day or night	5 (20)	13 (26)	12 (33)	1 (11)
Increased cough or phlegm	6 (24)	9 (18)	10 (28)	1 (11)
Shortness of breath	4 (16)	11 (22)	12 (33)	1 (11)
Asthma	- -	- -	1 (3)	- -

***p<0.05**

Results on the prevalence of respiratory symptoms by age are shown in Table 4.14 and there were no statistically significant differences in the prevalence of respiratory symptoms based on the age of the quarry workers. In the control group, however, prevalence of cough was significantly higher at 35% among respondents aged 40 years or older compared to the younger age groups (p=0.01). Shortness of breath in the control group was also significantly higher among those aged 40 years and older (35%) than it was among younger respondents (p=0.04).

Table 4.14: Prevalence of respiratory symptoms by age

Quarry Workers (n=120)	Frequency and percentage (%)					
	18-29 years (n=45)		**30-39 years (n=49)**		**≥40 years (n=26)**	
Cough	23	(51)	32	(65)	13	(50)
Phlegm in the morning	9	(20)	18	(37)	4	(15)
Phlegm during day or night	9	(20)	18	(37)	4	(15)
Increased cough or phlegm	7	(16)	15	(31)	4	(15)
Shortness of breath	12	(27)	11	(22)	5	(19)
Asthma	-	-	-	-	1	(4)
Non-exposed group (n=96)	**18-29 years (n=41)**		**30-39 years (n=32)**		**≥40 years (n=23)**	
Cough	1	(2)	4	13	**8**	**(35) ***
Phlegm in the morning	-	-	1	(3)	2	(9)
Phlegm during day or night	-	-	1	(3)	1	(4)
Increased cough or phlegm	-	-	-	-	1	(4)
Shortness of breath	4	(10)	9	(28)	**8**	**(35) ***
Asthma	-	-	-	-	-	-

***p<0.05**

Table 4.15 shows the prevalence of respiratory symptoms among study participants who used electric compared to those who used non-electric sources of fuel for cooking. There were no statistically significant differences in the prevalence of respiratory symptoms based on the type of fuel used for cooking by quarry workers. In the non-quarry sample, however, the prevalence of cough was significantly higher at 20% for community members who used non-electric sources (p=0.03). Shortness of breath in the control group was also significantly higher (29%) among respondents who used non-electric sources (p=0.04).

Table 4.15: Prevalence of respiratory symptoms by cooking fuel type

Quarry Workers (n=120)	**Electric (n=5)**		**Non-electric (n=115)**	
Cough	3	(60)	65	(57)
Phlegm in the morning	2	(40)	29	(25)
Phlegm during day or night	2	(40)	29	(25)
Increased cough or phlegm	-	-	26	(23)
Shortness of breath	-	-	28	(24)
Asthma	-	-	1	(1)
Non-exposed group (n=96)	**Electric (n=41)**		**Non-electric (n=55)**	
Cough	2	(5)	**11**	**(20) ***
Phlegm in the morning	-	-	3	(6)
Phlegm during day or night	1	(2)	1	(2)
Increased cough or phlegm	-	-	1	(2)
Shortness of breath	5	(12)	**16**	**(29) ***
Asthma	-	-	-	-

$*p<0.05$

Prevalence of respiratory symptoms is shown according to smoking history for both the quarry workers and the non-exposed participants in Table 4.16. The chi-square test of association results showed that differences in the prevalence of symptoms by smoking history were not statistically significant.

Table 4.16: Prevalence of respiratory symptoms by smoking

Quarry Workers (n=120)	**Smokers (n=26)**	**Non-smokers (n=94)**
Cough	13 (50)	55 (59)
Phlegm in the morning	6 (23)	25 (27)
Phlegm during day or night	6 (23)	25 (27)
Increased cough or phlegm	6 (23)	20 (21)
Shortness of breath	5 (19)	23 (25)
Asthma	- -	1 (1)
Non-exposed group (n=96)	**Smokers (n=5)**	**Non-smokers (n=91)**
Cough	- -	13 (14)
Phlegm in the morning	- -	3 (3)
Phlegm during day or night	- -	2 (2)
Increased cough or phlegm	- -	1 (1)
Shortness of breath	- -	21 (23)
Asthma	- -	- -

***p<0.05**

4.1.4.5. Quarrying as a risk factor for respiratory symptoms

A logistic regression model was run to identify risk factors for respiratory symptoms. The process involved an initial run of univariable models to identify variables suitable for inclusion in the subsequent multivariable model. A less strict cut off p-value of 0.25 was set for the selection of variables to include the final model. This was done to avoid excluding variables that are known to have an effect in relation to respiratory diseases.

The variables that were included in the multivariable model were gender, age, type of cooking fuel, exposure to quarry work and length of exposure and Table 4.17 presents the odd ratios for the respiratory symptoms by the above predictor variables. First, quarry workers were significantly more likely to report coughing than non-exposed participants (OR=8.52, 95% CI: 2.57-28.29). Quarry workers were also significantly more likely to report phlegm in the morning than non-exposed participants (OR=8.94, 95% CI: 1.46-54.73). However, quarry workers were significantly less likely to report shortness of breath compared to non-exposed participants (OR=0.26, 95% CI: 0.09-0.72).

Apart from the quarry workers versus the non-exposed group odds comparisons above, the results show that users of non-electric fuel were significantly more likely to report shortness of breath compared to users of electric sources (OR=3.13, 95% CI: 1.03-9.52). Males were also significantly more likely to report shortness of breath compared to females (OR=4.19, 95% CI: 1.44 -12.15).

The socio-demographic profiles of the study participants are presented in Table 4.1 and of the 120 quarry workers, 114 (95%) were male and only 6 (5%) were female. In contrast, of the 96 non-exposed respondents, 79% were female and 21% were male. The mean age, height, weight and BMI for the quarry workers were all highly comparable to corresponding measures in the control group.

Table 4.17: Adjusted odd ratios for respiratory symptoms

Variables	Cough		Phlegm in the morning		Phlegm during day/night		Increased cough/phlegm		Shortness of breath	
	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI	Adjusted OR	95% CI
Gender	0.66	0.20 - 2.19	1.00	0.20 – 5.11	1.08	0.18 – 6.37	3.79	0.33 – 43.02	**4.19***	1.44 – 12.15
Age	2.33	1.00 - 5.46	0.49	0.17 – 1.45	0.39	0.12 – 1.22	0.59	0.18 – 1.95	1.97	0.80 – 4.86
Type of cooking fuel	2.77	0.91 - 8.42	1.47	0.27 – 7.91	0.52	0.10 – 2.64	-	-	**3.13***	1.03 – 9.52
Exposure to quarry work	**8.52***	2.57 -28.29	**8.94***	1.46 – 54.73	**19.05***	2.16 – 168.26	6.61	0.61 – 71.61	**0.26***	0.09 – 0.72
Length of exposure	1.42	0.39 - 5.12	0.36	0.04 – 3.16	0.21	0.02 – 1.92	0.24	0.03 – 2.23	0.21	0.04 – 1.08

$*p<0.05$, OR= Odds ratio

Predictor variables	**Reference categories**
Gender	• Female • Male
Age	• 18-29 years • 30-39 years • ≥40 years
Type of cooking fuel	• Electric • Non-electric
Exposure to quarry work	• Non-exposed community members • Quarry workers
Length of exposure	• 1-3 years • 4-6 years • 7-9 years • 10 years+

4.1.5. Discussion and Conclusion

Respirable dust exposure greatly differed among the work sites as well as job categories. The study found varying dust levels across all four sites, with Site A having the highest exposure and Site B having the least exposure. This trend follows study results by Kwaansa-Ansah, Kwaku Armah, and Opoku (2017) who established varying mean concentrations of respirable dust from four different locations ranging from 0.02-4.26 mg/m3 in Ghana quarry mines. From the four locations, the highest location (Shaft A) recorded a mean concentration of 1.07 while the least location (Shaft D) recorded a mean concentration of 0.88 mg/m3.

The peak dust exposure limit was below NOIH's respirable dust exposure limits of 1.0 mg/m3. This is an indication that all sites under study were generating dusts within permissible levels. This suggested a reduced risk of exposure to respiratory health effects. These results contrast with Hamatui, Naidoo, and Kgabi (2016) who discovered high charcoal dust exposure levels that exceeded the US OSHA endorsed limit of 3.5 mg/m^3 with factories 1 and 3 bearing the peak dust levels of 25.9 mg/m^3 and 19.4 mg/m^3 respectively. Also, findings from a different study by Naidoo et al. (2006) showed that the highest location (1.07 mg/m3) exceeded NOISH repairable dust levels. Higher concentration values give an indication of the greater extent of the exposure of respirable dust. Variations in dust exposure within sites were as a result of differences in dust generation from various worksites where designated job categories are placed.

Within the entire sites, the excavation job category was the highly exposed and wire saw was the least exposed. Excavation produced more dust due to the process of rigging and rubble moving. Wire saw had the least exposure because water wetting method was used hence the amount of dust generated during working was dissuaded. These findings concur with Olusegun, Adeniyi and Adeola (2009) who revealed that excavation generated high dust amounts in comparison to other selected jobs within the quarrying sites. The increase in dust content was attributed by drilling and mobility of machinery during the mining processes. In contrast, a study by Draid et al. (2015) revealed that the crusher had the highest dust concentrations compared to other job categories.

For all the job categories, dust exposure was below NOISH recommended exposure limits. This finding was acknowledged by Kwaansa-Ansah, Kwaku Armah, and Opoku (2017) who revealed that minimum dust concentration for all job categories (Teledyne Operators, Equipment Operators, Long Hole Drillers Blast men, Machine Drivers and Grouters) were below the NIOSH recommended value.

Blastmen recorded a minimum concentration range of 0.3346 ± 0.118 mg/m3, whereas Teledyne Operators recorded the least range (0.223 ± 0.125 mg/m3) for respirable dust.

Quarry workers (0.85 mg/m³) were relatively more exposed to respirable dust than community members (0.62 mg/m³). This variation in exposure was attributed to differences in exposure times and distance from the source of dust generation. These findings cohere with Sumana et al. (2016) who established varying levels of dust concentration as the distance from the source either increased or decreased. The mean dust concentration levels from the source at 0m were 0.165mg/m3, at 200m was 0.04mg/m3 and at 500m was 0.005mg/m3. In the same study, a negative correlation coefficient affirmed a reduction in dust concentration levels as the distance from the source increased as well. The decrease in dust concentration due to the increase in distance from the source is as a result of the dilution effect caused by the wind. The more distance travelled by dust particles the more they become diluted by wind action. Results by Babatunde (2013) from a different study showed that mean dust concentrations decreased significantly with increased distance.

There was no statistically significant association between the dust exposure categories and prevalence of respiratory symptoms among the quarry workers. However, respiratory symptoms were reported among quarry workers (exposed) more than in community members (non-exposed). Binomial logistic regression models ran, statistically showed that quarry work was a significant predictor for cough, phlegm in the morning, phlegm during the day or night, and increased cough or phlegm ($p<0.05$). The current study results are in linearity with by Nwibo et al. (2012) who discovered that quarry workers had developed several respiratory ailments which consisted of shortness in breath, wheezing, coughing and chest pains. Ugbogu et al. (2009) confirmed close to 85% incidences of respiratory health effects (signalled by respiratory symptoms) amongst quarry manual stone workers. A study by Oguntoke et al. (2009) in Abeokuta Ogun State, Nigeria, found out that only quarry workers had developed respiratory symptoms than community members. Kumar et al. (2014) concurs that wheezing and coughing had five to six times of incidence among the exposed compared to the non-exposed. This suggests that continued exposure to dust from quarrying activities bears the capability of increased susceptibility to respiratory health effects.

Among the quarry workers, cleaners recorded the highest prevalence of respiratory symptoms yet they were the least exposed group. Study findings by Shadab et al. (2013) showed that respiratory symptoms such as phlegm, coughing and wheezing were commonly found among sweepers (cleaners). This can be attributed to the fact that cleaners were more exposed to mineral and organic dust from cleaning and they lacked sound respiratory protection equipment. Cleaners could have been assigned light duties because of their ill health conditions which might include coughing and some other respiratory conditions. These findings point out that quarry workers' risk for developing respiratory symptoms is influenced mainly by individual factors and to a lesser extent exposure to dust.

There were several limitations in the study. Firstly, the unwillingness to participate in the study by some quarry sites prevented the study to perform random sampling in choosing the sampling frame. However, the researcher is confident that the sample was representative of quarry workers in Namibia as employment strategies do not vary across quarry mines. Furthermore, personal dust exposure and lung function tests were not performed on all workers. Untested workers were not substantially different with regards to reported health outcomes, duration of employment, or exposure compared to those on whom the tests were performed. Moreover, resource restrictions prevented the study from undertaking more extensive exposure assessments. The study based its findings on a single phase of revelation valuations based on work descriptions. This approach does not permit the determination of variations in exposure across a prolonged work period. Workplace observations were conducted by a member of the research team at the time of the sampling who found no evidence that the work practices on the day of monitoring differed meaningfully from other days or, according to key informants at each site, from the recent past. Because of the absence of historical data, the study could not assess records and the models assumed that the current exposures were reflective of the past exposures. This is likely to be a valid assumption as there was no evidence that current work processes have varied from the past: there have been no new mechanisations, exposure controls, or ventilation improvements introduced since the quarries started operating.

The study did not review records as there was none available, as well as the chest x rays that could not be performed could not account for their potential confounding effects. While the study findings can be generalized to Namibian quarry workers, differences in applied processes, technologies, use of protective equipment, and working conditions may limit the generalisability to other countries. Despite these shortcomings, there are important strengths to the study. To our knowledge, it is the first study among quarry workers that includes exposure assessments. Our exposure assessments were performed using NIOSH standardized procedures, interviews were conducted using validated instruments, and experienced technicians conducted spirometry assessments. As a result of these strengths, we were able to measure dust-related adverse respiratory outcomes in a dose-response manner.

4.1.6. Recommendations

A key recommendation based on our findings is the need to monitor the health states of workers on a regular basis by performing occupational medical examinations (pre, ongoing and post-tests). This is particularly so as the study found that there were no medical examinations records at any of the studied sites. Study results signal the need for effective preventive dust exposure interventions in the quarries. The establishment of a watchdog agency will help in the enforcement of dust control measures in the quarries. However, the prescribed interventions should be low cost and incorporate medical surveillance. Moreover, environmental management systems which include a dust management plan should be employed at the quarries in order to mitigate dust generation. Dust monitoring should be carried out so as to establish dust exposure levels of different job categories. Establishment of dust exposure levels streamlines adherence to the standards and limits of the concentrations of the dust generated from the different stages of their operations. The quarry workers should be adequately sensitised on the adverse health effects of exposure to quarry dust and the importance of using personal protective equipment while at work. Collaboration of all stakeholders in quarry mining by the Namibian government, through the Ministry of Health and Social Services and Ministry of Labour and Social Services, should enforce occupational health and safety-related standards to protect the health of workers in quarry mines.

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ARTICLE 2: ASSESSMENT OF THE ASSOCIATION BETWEEN DUST EXPOSURE AND LUNG FUNCTION AMONG QUARRY WORKERS AND COMMUNITY MEMBERS, KARIBIB, NAMIBIA 2018

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4.2.1 Abstract

The purpose of this study was to assess the association between dust exposure and lung function among quarry workers and community members in Karibib, a small mining town in the Erongo region. The study followed a cross-sectional descriptive study. The study population was taken from 4 quarry mines based on their availability and willingness to participate. The population included full time workers from the 4 sites.

In this study, lung function did not show any significant differences with regards to job category and site. However, the study found a significant difference in predicted lung functions (FVC, FEV1/FVC, and PEF) between quarry workers and community members. Eleven percent (11%) of quarry workers recorded obstructive or restrictive lung functions as compared to none from the community. Obstructive or restrictive lung functions among the quarry workers could have been contributed by the number of working years exposed. Ten (10) out of thirteen (13) (i.e. 77%) quarry workers with obstructive or restrictive lung function had been working in quarry mine for 4 years and beyond. This signifies that occupational dust exposure for more than four years plays a significant role in decreasing lung function, thereby increasing the risk of respiratory symptoms. In conclusion, the study did not find a link between the respiratory diseases and dust exposure which could be that the dust levels at the research sites were low – which would be a good thing. The only significant relationship relating to dust exposure that has been found is with the lung function assessment (FEV1/FVC Pred%).

A key recommendation based on the findings is the need to monitor the health states of workers on a regular basis by performing occupational medical examinations (pre, ongoing and post-tests). Regular environmental audit and monitoring of quarrying activities should be enforced in order to ensure adherence to the standards and limits of the concentrations of the dust generated from the different stages of their operations. The quarry workers should be adequately sensitized on adverse

health effects of exposure to quarry dust and the importance of using personal protective equipment while at work.

4.2.2 Introduction (Background of the study)

Quarrying activities generate a significant amount of dust that may affect the health of people. Stone quarry dust comprises of both fine and coarse particulate matters that have varying adverse effects on the body, particularly on the respiratory organs. The multistage process of stone quarry includes the extraction of the rocks mechanically from the ground and crushing them to produce stones of various sizes for immediate use or for further processing to manufacture secondary products (Nwibo, Ugwuja, Nwambeke, Emelumadu, & Obgbonnaya, 2012). Every stage of these processes produces dust that poses risks to those exposed.

Decreased lung function, increased hospital admissions, mortality from cardiopulmonary death and cardiovascular symptoms are mainly associated with respirable dust penetrating deep into the lungs and entering the blood circulatory system (Millers et al., 2013). Exposure to high amounts of fine particulate matter above TWA (Time Weighted Average) can lead to death and cardiovascular symptoms since it can penetrate deep into the lungs and enter the blood circulatory system (Naidoo, Robins, Seixas, Lalloo, & Becklake, 2006). Exposure to dust such as crystalline silica mainly at the point sources in aggregate quarries thus increases the risk of diseases to workers.

Airborne dust particles are of serious concern due to their link with occupational respiratory diseases such as pneumoconiosis, chronic obstructive pulmonary disease and occupational asthma (Esswein, Kiefer, John Snawder, & Breitenstein, 2012). Quarry work is a typical example of activities that generate a significant amount of respirable dust where exposure is detrimental to human health. Incidences of chronic bronchitis, emphysema, acute and chronic silicosis, and lung cancer, among others were reported in a study in Nigeria as a result of exposure to dust by quarry workers (Nwibo et al., 2012).

The risk to air quality associated with a quarry is caused by the release of dust from the day to day activities including drilling, blasting, extraction and processing of hard rock, material handling, stockpiling and haulage of raw materials and final products (Aloh, 2008). Disregarding safety regulations by some employers with the sole aim of maximising profits through none provision of safety materials and conducive working environment affects the health of workers. The development of respiratory diseases as a result of lack of adequate safety measures by workers in quarry industries has been reported (Naidoo et al., 2006).

Naidoo, et al (2006) reported decreases in FEV 1 of up to 27.5 ml/mg-year/m 3 among new miners while 15-year cumulative exposure related declines of 5.9 ml in FEV 1 per mg-year/m 3. Henneberger and Attfiel (1996) in numerous cross-sectional studies noted an increased effect among new miners compared with old miners due to their differences in cumulative exposures. Henneberger and Attfield (1996) showed that hired mine workers had increased dust related effects on FEV 1 more than longer term workers (–5.9 ml in new compared to À1.2 ml/mg-year/m 3).

Epidemiological evidence is required to unravel this complexity in the Namibian quarrying industry. The quarry industry in Namibia is an important business sector, which contributes to the economy and employs quite a sizeable number of workers. These workers are susceptible to a high risk of exposure to these fine particulate matters.

After extensive literature search, there were no findings on studies conducted in the country that assessed the health impact of the quarry activities on the health of workers to the best knowledge of the researcher. Hence, the research aimed to evaluate the risk and prevalence of respiratory diseases because of potential exposure to dust by quarry workers.

4.2.3 Study Method

4.2.3.1 Research Design

The study adopted a quantitative and analytic approach. A quantitative approach was used to compare the effects of dust on the exposed and non-exposed group. An analytical approach measured the lung functioning of both the quarry workers and community members thus evaluating the risk associated with dust exposure.

4.2.3.2 Study Site

The study was conducted in Erongo region, at the outskirts of Karibib town (21° 56' 12.0516'' S and 15° 51' 40.7628'' E). Karibib town is located near River Khan, along the B2 (Trans-Kalahari) highway, centrally placed between Swakopmund and Windhoek. The B2 highway links Johannesburg and Walvis Bay. Erongo has more than 8 quarry mines thus bearing the highest number of quarry mines in Namibia. Due to ethical considerations, the name of the study sites in this research were referred to as Quarry A, B, C, and D.

4.2.3.3. Study Population

According to Namibia Statistic Agency (2011), Karibib has an estimated population of 16 807 inhabitants as calculated using the growth rate of 3.4% per year and it sits on 97 square kilometres of town land. The Ministry Mines and Energy (2018) reports that approximately 17,000 people were employed by the mining and quarry sector in 2017, with 9,643 permanent employees, 889 temporary employees and 6,373 contractors. The study population consisted of 4 quarry sites which were selected on the basis of availability and willingness to participate. All quarry workers (exposed) and community members (non-exposed) from different sites meeting the inclusion criteria were invited to participate in the study.

4.2.3.4 Sample size

The sample size was calculated based on the country prevalence rate (4.1%) for respiratory diseases for 2014 (WHO, 2014). Sample size calculation formula: $n = 1.95^2 P (100-P)/E^2$, where **n** = sample size, **P** = proportion of the population with the desired factor, E = acceptable margin of error (5%).
$n = 1.95^2 x4.1 (100-4.1.)/5^2 = 60$ (59.8), plus 10% [6*7=42] of each of the following covariates (age, gender, smoking, history of TB, family history of respiratory related diseases, occupational history, other environmental factors) and 10 % for refusal. The final sample size was 113 participants each for quarry workers and community members. The total number of workers for the study was 113 and the number of community members was 113, thus a total sample of 226 was required for the study. The study sampled 120 quarry workers and 113 community members, thus having a total sample of 233 participants.

4.2.3.4.1 Sampling method

The study sampled 120 quarry workers using convenient sampling method from all 4 quarry sites and participated in self-administered questionnaires and lung function test. Convenient sampling was used because the target population was available at a certain time at the sites thereby making every subject available fit for participation. Random sampling was used to select a number of 113 participants from the community, with every 3rd household being selected on the basis of willingness to participate in the study. On average each site sampled 30 workers and 28 community members.

Typical purposive sampling was used to collect personal dust levels from 40 quarry workers because it enabled a comparison in the levels and amount of dust with different job categories. Personal dust levels were measured according to job categories so as to establish the job category with high, medium or low exposure levels.

Out of the 40 workers selected for personal dust sampling, 10 samples where purposely selected for silica analysis employing to the extreme or deviant style. Extreme or deviant purposive sampling enabled the researcher to further investigate outliers or participants that had shifted from normal established dust exposure level trend. Thus, participants with the highest dust exposure levels were referred for silica assessment.

4.2.3.4.2 Pilot study

A pilot study was conducted at quarry site F which was not included in the main study. The researcher approached and invited 10 participants. The participants demonstrated their consent by signing the consent form; some participants that were invited did not give consent and they were excluded from the study. The study procedures for data collection encountered some initial problems with the research instrument which had some offensive questions and some were repetitive and this did not go down well with the participants. In addition, the timing was inappropriate as most people preferred to be interviewed during lunch as the researcher had gone before lunch (around 11am). The processes of approaching and securing access to potential participants were initially rather frustrating due to the fact that some participants were not willing to participate and some did not want to disclose information during the interviews.

The pilot study provided a unique opportunity to improve the researcher's skills in using the questionnaire method in terms of approaching potential participants, selecting the interview environment and engaging in deep conversations. The offensive questions were rephrased to make them friendlier. The pilot study enabled the consideration of strategies to minimize these problems and ultimately determined the success of data collection during the main study.

4.2.3.4 Data collection

Data was collected using the following techniques:

4.2.3.4.3 Questionnaire method

A sample of 120 workers and 133 community members were interviewed with each participant being provided with a questionnaire which was guided by the researcher on ethical matters as well as answering of the questions. Questionnaires were administered at quarry workstations and surrounding community areas with ample time being given to complete them. The questionnaire was adopted from Miller et al (2005).

4.2.3.4.4 Lung function assessments

The lung function assessments were conducted using Spiro Bank II, and performed in accordance with the American Thoracic Society [ATS] criterion. Lung function tests were conducted to detect abnormalities associated with respiratory disorders. The tests were performed with a graphic representation of the manoeuvre with both flow-volume and volume-time displayed. The primary signal measured in spirometry may be volume or flow. These measurements included forced vital capacity (FVC), which is the volume delivered during expiration made as forcefully and completely as possible starting from full inspiration, and the forced expiratory volume (FEV) in one second, which is the volume delivered in the first second of an FVC manoeuvre. Other spirometric variables derived from the FVC manoeuvre were also addressed (Miller et al., 2005). A 3L calibration syringe was used to calibrate the instrument volume at the beginning of each shift and after every four hours. A minimum of 3 manoeuvres were performed per participant and the best trial was chosen on ATS criterial. The test was conducted to all 223 participants (thus 120 workers and 113 community members). Lung function test was conducted by a qualified technician who was hired by the researcher.

Results were presented in percentages of the predicted normal values. Comparisons were done between the reference value and an individual’s measured value. The table below shows the interpretation of lung function results.

Table 4.1: Interpretation of lung function results

Spirometry Test	Normal	Abnormal
FVC and EV1	Greater or equal to 80%	• Between 70 and 79% - Mild • Between 60 and 69% - Moderate • Below 60% - Severe
FEV1/FVC	Greater or equal to 70%	• Between 60 and 69% - Mild • Between 50 and 59% - Moderate • Below 50% - Severe

4.2.3.4.5 Personal dust sampling

A total of 40 quarry workers across all job categories were sampled for respirable dust assessment with every fourth filter selected for silica analysis. This means that out of 40 dust samples, 10 were sent for silica analysis. Personal dust sampling was conducted by means of a Gil Air RC Dust Sampling Pump using 37mm PVC filter operating at 2.2 volume, mean temperature of 25-30°C and relative humidity of 80-90 observing the NIOSH Method 0600. Sampling was done from 07h 00 to 15h 00 (eight hour full-shift), thus observing the Time Weighted Average (TWA) with selected workers wearing the pump at their work places.

Workers from each work category were randomly selected for personal dust sampling and an average of 3 samples being collected per job description. Results were extrapolated by work category in each factory. Because the country does not have an occupational exposure limit for carbon-containing material, dust exposure results were compared to the exposure limits set by the United States Occupational Safety and Health Administration (OSHA). Before use, the pumps were calibrated using a standard calibration pressure instrument. The pump flowrates were also constantly monitored.

4.2.3.5 Data analysis and interpretation

The collected data was analysed using Statistical Package for Social Sciences (SPSSS) version 22, after it was checked and cleaned. The Kolmogorov-Smirnov as well the Shapiro-Wilk tests showed that the data was non-normally distributed ($p<0.05$) and therefore non-parametric statistical methods were used in the subsequent bivariate and multivariate analysis. The chi-square test of association was used to compare the prevalence of the assessed health outcomes according to the quarry sites, years worked at the site, job descriptions and dust exposure levels. The chi-square test of association was also used to compare the prevalence of respiratory symptoms according to exposure to quarry work (i.e. between the quarry workers versus a sample of community members not involved in quarry work). In the case of variables measured on a continuous scale, the Kruskal-Wallis test as well as Spearman's rho correlational analysis were used to examine for relationships.

Logistic regression modelling was run to identify risk factors for respiratory symptoms. The process involved an initial run of univariable models to identify variables suitable for inclusion in the subsequent multivariable model. A less strict cut off p-value of 0.25 was set for the selection of variables to include the final model. This was done to avoid excluding variables that are known to have an effect in relation to respiratory diseases. The logistic regression models accounted for confounding variables such as age and gender, among others.

Dust exposure levels among the quarry workers were classified into three levels of low, medium and higher exposure. This was done by first calculating mean dust levels from the collected personal respirable dust levels and then extrapolating these mean dust levels to all similar exposure groups (SEG) such that all the quarry workers at all the sites in the study were allocated a mean dust level. Percentile groups on mean dust levels were then computed in SPSS to create three mean dust exposure levels as shown below.

Table 4.2: Mean dust exposure levels

Exposure level	Mean dust level (mg/m^3)	
	Minimum	**Maximum**
Low	0.13	0.55
Medium	0.56	1.03
High	1.04	2.19

In addition to the above mean dust exposure levels, cumulative dust exposure levels were also allocated to the quarry workers in the study. Cumulative dust exposure for each worker was calculated by multiplying the mean dust level per position by the number of years in the position. Percentile groups on cumulative dust levels were then computed in SPSS to create three cumulative dust exposure levels as shown below.

Table 4.3: Cumulative dust exposure levels

Exposure level	Cumulative dust level (mg/m^3)	
	Minimum	**Maximum**
Low	0.83	33.33
Medium	33.34	67.08
High	67.09	100.00

Unlike the respirable dust levels which were categorised into low, medium and high exposure as above, silica exposure was not categorised and was analysed as continuous data.

4.2.3.6 Ethical considerations

The researcher adhered to the following ethical standards:

- An informed consent form was signed and reinforced by verbal consent, clearly spelling to the participants the aim of the study as well as data collection procedures.
- Voluntary participation - participants were given the opportunity to choose whether or not to participate in the study. Participants had the liberty to withdraw from the study at any given time.
- Confidentiality was ensured through assigning numerical and alphabetical codes on data collection instruments so as to avoid identifying information (maintain anonymity).
- Permission to carry out the study was sought from Namibia University of Science and Technology and Ministry of Health and Social Services reference Number 17/3/3ss. Quarry operators also granted approval to collect dust samples for analysis.
- Risk/Beneficence was assured during data collection as the study participants were protected. Participants did not have any direct benefits associated to their participation; however, the implementation of the study recommendations might benefit them.

4.2.4 Results

4.2.4.1 Lung function

There were no statistically significant associations between the lung function assessments and quarry site, job specification, or years in quarrying among the quarry workers, as shown in Table 4.18. There were also no significant differences in the lung function measures between the quarry workers and the control group.

Table 4.4: Mean lung function among quarry workers and non-exposed participants

	Mean and standard deviation (SD)							
	FVC1 Pred%		FEV1 Pred%		FEV1/FVC Pred%		PEFR Pred%	
Quarry site								
Site A (n=27)	95.7	(14.0)	94.1	(14.8)	98.7	(8.8)	87.5	(15.0)
Site B (n=30)	100.9	(11.2)	101.4	(13.8)	100.5	(8.0)	92.2	(17.9)
Site C (n=30)	96.2	(13.5)	94.7	(15.6)	98.7	(9.8)	87.8	(15.7)
Site D (n=33)	100.5	(10.8)	100.4	(13.9)	99.9	(9.0)	90.3	(18.5)
Job specification								
Cleaner (n=12)	98.4	(13.8)	98.9	(15.8)	100.8	(8.1)	88.4	(14.1)
Drilling (n=18)	97.9	(13.9)	94.6	(17.8)	96.6	(11.2)	93.0	(19.2)
Excavator (n=21)	97.1	(12.7)	99.0	(15.9)	102.0	(8.4)	92.3	(18.6)
Loading (n=31)	100.5	(12.8)	99.4	(14.5)	99.2	(9.8)	84.5	(14.7)
Supervisor (n=16)	98.3	(11.5)	97.6	(12.2)	99.4	(6.8)	93.2	(19.6)
Wire Saw (n=22)	97.4	(11.3)	96.6	(13.4)	99.3	(7.6)	88.9	(15.2)
Years in quarrying								
1-3 years (n=25)	96.32	(14.27)	96.32	(14.11)	100.32	(7.67)	89.88	(14.14)
4-6 years (n=50)	98.70	(12.46)	97.98	(15.02)	99.50	(8.81)	90.36	(18.36)
7-9 years (n=36)	98.64	(12.26)	98.25	(15.69)	99.53	(9.48)	88.42	(16.25)
10 years or more (n=9)	102.11	(7.29)	99.11	(12.61)	97.00	(10.55)	88.00	(19.88)
Quarrying vs Non-exposed								
Quarry workers (n=120)	98.44	(12.44)	97.80	(14.72)	99.49	(8.85)	89.50	(16.86)
Non-exposed (n=96)	98.29	(12.51)	97.56	(12.82)	99.58	(7.75)	90.93	(15.09)

***p<0.05**

Table 4.19 presents results on lung function by levels of dust exposure and there were no statistically significant associations in this regard.

Table 4.5: Lung function by dust exposure levels among quarry workers (n=120)

Exposure category	Mean and standard deviation (SD)							
	FVC1 Pred%		FEV1 Pred%		FEV1/FVC Pred%		PEFR Pred%	
Low dust exposure (n=41)	97.6	(11.5)	95.5	(13.1)	98.1	(8.2)	86.8	(15.8)
Medium dust exposure (n=39)	102.2	(10.0)	100.9	(14.0)	98.8	(9.3)	88.8	(17.4)
High dust exposure (n=40)	95.7	(14.7)	97.1	(16.7)	101.7	(8.8)	93.0	(17.1)

***p<0.05**

There were no statistically significant associations between the lung function assessments cumulative dust category, as presented in Table 4.20 below.

Table 4.6: Lung function by cumulative dust levels among quarry workers (n=120)

Exposure category	**Mean and standard deviation (SD)**							
	FVC1 Pred%		**FEV1 Pred%**		**FEV1/FVC Pred%**		**PEFR Pred%**	
Low cumulative (n=40)	96.2	(12.1)	95.8	(12.8)	99.8	(6.8)	88.8	(15.1)
Medium cumulative dust (n=42)	101.5	(12.5)	99.0	(15.1)	97.7	(9.4)	89.8	(17.9)
High cumulative dust (n=38)	97.5	(12.3)	98.6	(16.3)	101.1	(9.9)	89.9	(17.8)

***p<0.05**

Results on the diagnosis of obstructive or restrictive lung functions are shown in Table 4.21 below. There were no statistically significant associations between quarry site (p=0.10), job specification (p=0.15) or years in quarrying (p=0.66) and the diagnosis of obstructive or restrictive lung functioning among the quarry workers. There was however a statistically significant difference in this regard between quarry workers and the control group, with 13 of the 120 of quarry workers (11%) diagnosed with obstructive or restrictive lung functioning compared to none of the 96 community members (p=0.01).

Table 4.7: Obstructive/restrictive lung functioning among quarry workers and non-exposed group

	Obstructive or restrictive	
Quarry site	Frequency and percentage (%)	
Site A (n=27)	6	(22)
Site B (n=30)	1	(3)
Site C (n=30)	4	(13)
Site D (n=33)	2	(6)
Job specification		
Cleaner (n=12)	1	(8)
Drilling (n=18)	1	(6)
Excavator (n=21)	0	(0)
Loading (n=31)	7	(23)
Supervisor (n=16)	1	(6)
Wire Saw (n-22)	3	(14)
Years in quarrying		
1-3 years (n=25)	3	(12)
4-6 years (n=50)	7	(14)
7-9 years (n=36)	2	(6)
10 years or more (n=9)	1	(11)
Quarrying vs Non-exposed		
Quarry workers (n=120)	**13**	**(11)***
Non-exposed (n=96)	0	(0)

***p<0.05**

4.2.4.2 Relationship between silica exposure and lung function among quarry workers

The correlation between silica exposure and the lung function assessments was examined using Spearman's rho correlation and as shown in Table 4.22, there was no significant correlation between the silica exposure and any of the lung function measures.

Table 4.8: Spearman's Rho correlation between silica exposure and lung function among quarry workers (n=10)

FVC1 Pred%	r_s	0.11
	p-value	0.77
FEV1 Pred%	r_s	-0.04
	p-value	0.91
FEV1/FVC Pred%	r_s	0.09
	p-value	0.81
PEFR Pred%	r_s	-0.04
	p-value	0.92

r_s =correlation coefficient, *p<0.05

4.2.4.3 Association between smoking and lung function among quarry workers

There was a statistically significant association between smoking history and the lung function assessments FEV1 Pred% (p=0.03). But there was no significant association between smoking and FVC1 Pred% (p=0.19) or FEV1/FVC Pred% (p=0.11) or PEFR Pred% (p=0.34)

Table 4.9: Mean lung function by smoking history among quarry workers (n=120)

	Mean and standard deviation (SD)			
Smoking history	**FVC1 Pred%**	**FEV1 Pred%**	**FEV1/FVC Pred%**	**PEFR Pred%**
Smokers (n=26)	95.2 (14.0)	**92.2 (14.7)***	97.0 (8.5)	86.2 (14.5)
Non-smokers (n=94)	99.4 (11.9)	**99.4 (14.4)***	100.2 (8.9)	90.4 (17.4)

***p<0.05**

4.2.4.4 Smoking as a risk factor for obstructive/restrictive lung function among quarry workers

Binomial logistic regression was done to predict the risk of obstructive or restrictive lung function from smoking among the quarry workers. Smoking was shown to be a significant predictor of lung function (OR=11.91, 95% CI: 3.29-43.13).

Table 4.10: Binomial logistic regression – smoking and lung function

	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Smoking	2.48	0.66	14.24	1.00	**0.00***	11.91	3.29	43.13
Constant	-3.11	0.51	37.13	1.00	0.00	0.04		

Exp(B)= adjusted odds ratio, *p<0.05

4.2.5 Discussion and conclusion

The study findings indicated that dust exposure was not associated with any deviations in lung functions. The study established high values for FEV1 and FEV1/FVC ratios (all > 80%), ruling a link with airflow restriction or obstruction due to dust exposure at work. This suggests that the amount of respirable dust exposed might be below NOISH recommended limits. Other factors could be a reduced duration of exposure as well as use of personal protective equipment thus limiting the amount of dust inhaled. However, this study result contrast with study results by Momyer (2016) who assessed the impact of mining environment on the respiratory function. Heads results demonstrated that surface (quarry) workers had a slightly increased loss in predicted FVC and FEV I percentages. Another contrasting evidence by Sumana et al. (2016) who measured cement production workers' lung function from 2007-2012 and witnessed a decrease in lung function for more than half of the workers over time due to constantly increased exposure to cement dust.

The study established a significant connection between smoking history and the lung function assessments (FVC1 Pred% and FEV1 Pred%). Furthermore, binomial logistic regression predicted that smoking among quarry workers posed a risk of obstructive or restrictive lung function. Smoking has been reported to impair lung function; this suggests that smoking could have been an exacerbating factor to obstructive or restrictive lung function among quarry workers. These findings are confirmed by Ugbogu, Ohakwe and Foltescu (2009), who alluded to evidence of lung function obstruction or restriction as measured by the FEV_1/FVC ratio emanating from tobacco smoking, with an established link between smoking and lowered FEV_1/FVC ratios. Suhr, Bang and Moe (2007) add that both FVC and FEV1 are decreased by smoking. This implies that smoking lowers lung volume resulting in airflow obstruction or restriction.

A simple linear regression analysis was done to assess if dust exposure was a significant predictor of the lung function assessment (FEV1/FVC Pred%) among the quarry workers. The unstandardized Beta coefficients indicated that a unit increase in dust level resulted in a corresponding 5.5 unit increase in FEV1/FVC Pred% ($t=2.75$, $p=0.01$). Thus, the higher the dust exposure levels among the quarry workers, the higher the FEV1/FVC Pred%. These study results diverge from Sufiyan and Ogunleye (2013) who predicted an annual yearly excess decline of 0.84 % FEV_1predicted. This explains that in 20 years more than 400 ml in lung capacity would have been lost.

Study findings revealed that there was no link between silica exposure and any of the lung function assessments. In the present study, the highest silica exposure was 0.54 mg/m3 which is below the NOISH exposure limit. This suggests that the development of silicosis was minimum as workers were not highly exposed to levels exceeding 50 µg/m3. The study findings contrast with Kwaansa-Ansah, Kwaku Armah and Opoku (2017) who found the mean concentration of silica crystalline for four sites ranging from 0.02 to 1.03 mg/m3 in Ghana. Shafts C and D exceeded the NOISH standard exposure limits (0.1 mg/m3) for and crystalline silica. A study by Momyer (2016) demonstrated varying silica content in dust from the three different rock types assessed. From the rocks assessed for silica, pozollana was highest with 35.92% and limestone was least with 3.26%. Overall, silica concentration was 0.62mg/m3 which is more than the recommended OSHA limit of 0.2mg/m3. In this regard, quarry workers had a high risk of developing respiratory health effects (mainly silicosis) due to their exposure.

There were no significant associations between smoking history and the respiratory symptoms among the quarry workers, meaning that out of those who never smoked reported respiratory symptoms indicating that dust exposure can be attributed to respiratory symptoms. According to Nwibo et al. (2012), in their investigation of pulmonary problems amongst quarry workers, they discovered that quarry workers had developed several respiratory ailments which consisted of shortness in breath, wheezing, coughing and chest pains. Data from the study suggests that continued exposure to dust from quarrying activities bear the capability of increased susceptibility to respiratory health effects as well as reduced lung function due to tobacco or cigarette smoking. Ugbogu et al. (2009) confirmed close to 85% incidences of respiratory health effects (signalled by respiratory symptoms) amongst quarry manual stone workers. Ilyas et al. (2010) found that respiratory health effects due to dust exposure were aggravated by non-usage of personal protective equipment by quarry workers as their employers were unable to provide protective equipment.

The study did not find a relationship between the respiratory diseases and dust exposure which could be that the dust levels at the research sites are low – which would be a good thing. It however could also be due to the small sample size (i.e. n=40). Altogether, the only significant relationship relating to dust exposure that has been found is with the lung function assessment FEV1/FVC Pred%).

There were several limitations in the study. Firstly, the unwillingness to participate in the study by some quarry sites prevented the study from performing a random sampling in choosing the sampling frame. However, the researcher is confident that the sample was representative of quarry workers in Namibia as employment strategies do not vary across quarry mines. Personal dust exposure and lung function tests were not performed on all workers. Untested workers were not substantially different with regards to reported health outcomes, duration of employment, or exposure compared to those on whom the tests were performed. Resource restrictions prevented the study from undertaking more extensive exposure assessments. The study based its findings on a single phase of revelation valuations based on work description. This approach does not permit the determination of variation in exposure across a prolonged work period. Workplace observations were conducted by a member of the research team at the time of the sampling, who found no evidence that the work practices on the day of monitoring differed meaningfully from other days or, according to key informants at each site, from the recent past. Because of the absence of historical data, the study could not assess records and the models assumed that the current exposures were reflective of the past exposures. This is likely to be a valid assumption as there was no evidence that current work processes have varied from the past as there have been no new mechanisations, exposure controls, or ventilation improvements introduced since the quarries started operating.

The study did not review records as there was none available, as well as the chest x rays that could not be performed and as such, they could not account for their potential confounding effects. While the study findings can be generalized to Namibian corrie quarry workers, differences in applied processes, technologies, use of protective equipment, and working conditions may limit the generalisability to other countries. Despite these shortcomings, there are important strengths to the study. To our knowledge, it is the first study among quarry workers that includes exposure assessments. Our exposure assessments were performed using NIOSH standardized procedures, interviews were conducted using validated instruments, and experienced technicians conducted spirometry assessments. As a result of these strengths, we were able to measure dust-related adverse respiratory outcomes in a dose-response manner.

4.2.6 Recommendations

Based on the study results the following is recommended.

- There is need to establish a watchdog agency which enforces the proper execution of health and safety policies and suitable workplace controls to reduce dust exposure in quarries. Effective dust exposure preventive interventions will be adhered to. For instance, the watchdog agency should ensure that workers undergo intermittent medical examinations.
- Quarry workers and surrounding communities should be equipped with dust exposure health information in regards to health risks, suitable working conditions, personal hygiene and preventive measures. This initiative will help them in making informed decisions as well as compliance to set standards and regulations.
- Since most quarries are within an informal setting, collaboration of key stakeholders is vital. The Namibian Ministry of Health and Social Services, Ministry of Labour, and all informal sector stakeholder's teaming up together will ensure safe working conditions and positive health outcomes within Namibian quarry workers and surrounding communities.
- Effective dust control exposure and employee protection is more effective when the level of dust exposure is detected. In light of this, dust monitoring should be done so as to assess the level of employee exposure at different locations thereby ascertaining the intensity of risk which allows for appropriate control measures and interventions to be instituted.

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CHAPTER FIVE: GENERAL DISCUSSIONS AND CONCLUSIONS

Respirable dust exposure greatly differed among the work sites as well as job categories. The study found varying dust levels across all four sites with Site A having the highest exposure and Site B having the least exposure. However, the highest dust exposure limit at Site A was below the international recommended limits. Within all the sites, excavation job category was the highly exposed and wire saw was the least exposed. This could be because at the wire saw of all sites they used water which reduced the amount of dust generated during working. Variations in dust exposure within sites were as a result of differences in dust generation from various worksites where designated job categories are placed. The study revealed a higher level of dust exposure of quarry workers (0.85 mg/m^3) as compared to community members (0.62 mg/m^3). This was attributed by the fact that community members had limited time and amount of exposure to dust as compared to quarry workers. Thus, quarry workers spent more time in dusty environment than community members.

Among the quarry workers, cleaners (75%) recorded the highest prevalence and the lowest was for excavators (48%). Prevalence of phlegm was also highest among cleaners (58%) followed by wire saw (41%). The least exposed job category (Cleaners) significantly had more respiratory symptoms of coughing and phlegm as compared to the most exposed job category (excavator) which recorded the least respiratory symptoms. This result rules out an association of high dust exposure with respiratory symptoms. Thus, the prevalence of respiratory symptoms such as coughing and phlegm were more on the least exposed workers than the highly exposed workers. These respiratory symptoms among cleaners could be attributed to age, socio-economic status, and health status. Cleaners could be assigned light duty because of their ill health conditions which might include coughing and some other respiratory conditions. These findings point out that quarry workers' risk for developing respiratory symptoms is influenced mainly by individual factors and to a lesser extent exposure to dust.

Silica exposure levels did not reflect any significant differences with regards to job category and site as the OSHA recommended level of 50 µg/m3 was not exceeded. Silica tests were only conducted on quarry workers not community members.

The risk of experiencing respiratory symptoms can also be associated with the type of energy used for cooking. Household indoor air quality is largely compromised by the type or source of energy used for cooking as fossil fuels smoke emission exposure reported a higher incidence of poor respiratory health. The study established an association between coughing and type of energy used with reference to community members and quarry workers' respiratory symptoms. Quarry workers were significantly more affected by coughing and phlegm as compared to community members (community members have 88% less risk for cough than quarry workers). In this study, 63% of quarry workers used wood followed by gas at 32%, with minimum electrical usage. A total of 41% of community members used electricity while 43% used wood. This means that more than half of quarry workers using wood for cooking had poor air quality due to wood smoke as compared to less than half (41%) of community members that are exposed to wood smoke.

Lung function did not show any significant differences with regards to job category and site either. However, the study found a significant difference in predicted lung function (FVC, FEV1/FVC, and PEF) between quarry workers and community members. Eleven percent (11%) of quarry workers recorded obstructive or restrictive lung function as compared to none from the community. Obstructive or restrictive lung function among the quarry workers could have been contributed by the number of working years exposed. Ten (10) out of thirteen (13) (i.e. 77%) quarry workers having obstructive or restrictive lung function had been working in the quarry mine for four years and beyond. This signifies that occupational dust exposure for more than four years plays a significant role in decreasing lung function thereby increasing the risk of respiratory symptoms. Additionally, the study also established that there were more quarry workers who had a smoking history as compared to community members, with smoking prevalence being high at Site B. Collectively, 78% of the quarry workers had never smoked compared to 95% among community members. Smoking has been reported to impair lung function, meaning that in this study smoking could have been an exacerbating factor to obstructive or restrictive lung function among quarry workers as they had been exposed to smoking more than community members.

The study could not find significant models on respiratory disease risk odds using logistic regression because it has already seen that the respiratory symptoms are not linked to dust levels (i.e. there are no real differences in dust level exposure between those who coughed or did not cough, those who experienced phlegm or did not experience phlegm etc.). The study did not find a link between respiratory diseases and dust exposure which could be that the dust levels at the research sites are low, which would be a good thing. It however could also be due to the small sample size (i.e. n=40). Altogether, the only significant relationship relating to dust exposure that has been found is with the lung function assessment (FEV1/FVC Pred%).

There were several limitations in this study. Firstly, the unwillingness to participate in the study by some quarry sites prevented the study from performing a random sampling in choosing the sampling frame. However, the researcher is confident that the sample was representative of quarry workers in Namibia as employment strategies do not vary across quarry mines. Furthermore, personal dust exposure and lung function tests were not performed on all workers. Untested workers were not substantially different with regards to reported health outcomes, duration of employment, or exposure compared to those on whom the tests were performed. Resource restrictions prevented the study from undertaking more extensive exposure assessments. The study based its findings on a single phase of revelation valuations based on work description. This approach does not permit the determination of variations in exposure across a prolonged work period. Workplace observations were conducted by a member of the research team at the time of the sampling who found no evidence that the work practices on the day of monitoring differed meaningfully from other days or, according to key informants at each site, from the recent past. Because of the absence of historical data, the study could not assess records and the models assumed that the current exposures were reflective of the past exposures. This is likely to be a valid assumption as there was no evidence that current work processes have varied from the past as there have been no new mechanisations, exposure controls, or ventilation improvements introduced since the quarries started operating.

The study did not review records as there was none available, as well as the chest x rays that could not be performed and such could not account for their potential confounding effects. While the study findings can be generalized to Namibian quarry workers, differences in applied processes, technologies, use of protective equipment, and working conditions may limit the generalisability to other countries. Despite these shortcomings, there are important strengths to the study. To our knowledge, it is the first study in Namibia conducted among quarry workers that includes exposure assessments. Our exposure assessments were performed using NIOSH standardized procedures, interviews were conducted using validated instruments, and experienced technicians conducted spirometry assessments. As a result of these strengths, we were able to measure dust-related adverse respiratory outcomes in a dose-response manner.

CHAPTER 6: RECOMMENDATIONS

A key recommendation based on our findings is the need to monitor the health states of workers on a regular basis by performing occupational medical examinations (pre, ongoing and post-tests). This is particularly so as the study found that there were no medical examinations records at any of the studied sites. Study results signal the need for effective preventive dust exposure interventions in the quarries. The establishment of a watchdog agency will help in the enforcement of dust control measures in the quarries. However, the prescribed interventions should be low cost and incorporate medical surveillance. Moreover, environmental management systems which include a dust management plan should be employed at the quarries in order to mitigate dust generation. Dust monitoring should be carried out so as to establish dust exposure levels of different job categories. Establishment of dust exposure levels streamlines adherence to the standards and limits of the concentrations of the dust generated from the different stages of their operations. The quarry workers should be adequately sensitised on the adverse health effects of exposure to quarry dust and the importance of using personal protective equipment while at work. Collaboration of all stakeholders in quarry mining by the Namibian government, through the Ministry of Health and Social Services and Ministry of Labour and Social Services, should enforce occupational health and safety-related standards to protect the health of workers in quarry mines.

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APPENDICES

APPENDIX A: PERMISSION LETTER FROM MOHSS

REPUBLIC OF NAMIBIA

Ministry of Health and Social Services

Private Bag 13198 Windhoek Namibia	Ministerial Building Harvey Street Windhoek	Tel: 061 – 2032150 Fax: 061 – 222558 Email: shimenghipangelwa71@gmail.com

OFFICE OF THE PERMANENT SECRETARY

Ref: 17/3/3 **SS**
Enquiries: Mr. J. Nghipangelwa

Date: 16 November 2017

Ms. Saima Shihepo
Namibia University of Science and Technology
Windhoek
Namibia

Dear Ms. Shihepo

Re: Assessment of dust exposure and risk of chronic respiratory diseases among corrie quarry workers in Namibia

1. Reference is made to your application to conduct the above-mentioned study.
2. The proposal has been evaluated and found to have merit.
3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**

3.1 The data to be collected must only be used for academic purposes;

3.2 No other data should be collected other than the data stated in the proposal;

3.3 Stipulated ethical considerations in the protocol related to the protection of Human Subjects' should be observed and adhered to, any violation thereof will lead to termination of the study at any stage;

3.4 A quarterly report to be submitted to the Ministry's Research Unit;

3.5 Preliminary findings to be submitted upon completion of the study;

3.6 Final report to be submitted upon completion of the study;

3.7 Separate permission should be sought from the Ministry of Health and Social Services for the publication of the findings.

Yours sincerely,

Andreas Mwoombola (Dr.)
Permanent Secretary

PERMANENT SECRETARY MINISTRY OF HEALTH & SOCIAL SERVICES

APPENDIX B: CONSENT FORM

Consent form

Dust Exposure and risk of chronic respiratory diseases among quarry workers in Namibia.

Dear participant

My name is Saima Shihepo I am a student at Namibia University of Science and Technology, undertaking a Masters Degree in Health Sciences. I am carrying out a study assessing the dust exposure levels and respiratory health outcomes among quarry workers in Namibia: A cross sectional study. I am kindly requesting you to participate in my study.

The information obtained in this study will be used to assess the dust exposure levels and respiratory health outcomes among quarry workers in Namibia. Appropriate authorities have approved the study and its procedures. Responding to questions asked, will take maximum 20 minutes. You are free to ask any questions about the study at any time if you need more clarifications.

Your participation is voluntary and you are free to withdraw anytime without any penalties. Your decision to participate or not will not implicate you or your relationship with your organization or higher level of authority. The information obtained from you will be coded so that they are not linked to your name and your identity will not be revealed at any time of the study. All data will be kept in a secure place and will not be shared with any other person without your permission.

If you agree to participate may you please sign in the space provided below?

Participant signature …………………….. Date…………………

APPENDIX C: PERMISSION TO CONDUCT RESEARCH STUDY IN YOUR ORGANIZATION

University of Science and Technology
Private Bag 13388
Windhoek
Namibia
Date: 29 January 2018

…………………………………….

……………………………………

……………………………………

Dear Sir/Madam

Re: Request for permission to conduct research study in your organization.

My name is Saima Shihepo and I am a final year Masters student at Namibia's University and Technology, studying towards a Masters in Health Science. I am conducting a study on **Assessment of Dust Exposure and Risk of Chronic Respiratory Diseases among stone corrie quarry workers in Namibia.**

The study will focus on small Quarry mines; thus, I am hereby requesting permission to conduct my study in your Organisation.

Following this cover letter is the proposal to the project I wish to conduct and the approval letter from the Ministry of Health and Social Services. The significance of this study is stipulated in the proposal as well as all the ethics that will be considered.

Thank you for your assistance.

I am looking forward to your reply.

Yours Faithfully

Saima Shihepo

Contact number (0813225437)

APPENDIX D: QUESTIONNAIRE

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Health and Applied Sciences

QUESTIONNAIRE

Dust Exposure and Risk of Chronic Respiratory Diseases among stone quarry workers in Namibia

STUDY ID ___________

Please insert the date when the questionnaire was completed on the space provided

DATE: ___/___/___

CONSENT

Having read the information provided in the Participant Information Sheet, if you are willing to participate in this study please indicate so by ticking the relevant box below. To protect your privacy, no consent signature is requested. PLEASE NOTE THAT by completing this questionnaire you are consenting to taking part in this study.

I hereby confirm that I am willing to participate in this study.

Y	N

Instructions

- No names are required.
- Please answer all questions by ticking/filling the appropriate box of your choice.
- Skip any question which is not appropriate for you.

Quarry Number: ____________________

SECTION A. GENERAL INFORMATION

1. AGE LAST BIRTHDAY ______

2. SEX

M	F

3. MARITAL STATUS:

a. MARRIED __

b. WIDOWED __

c. DIVORCED __

d. SEPARATED __

e. NEVER MARRIED __

4. Employment Status (tick appropriate box)

(a) Self-employed ☐

(b) Employee ☐

5. (a) Part-time ☐

(b) Full-time ☐

6. If part-time what other work(s) are you engaged in

…………………………………………………………………………………….

7. How many years have you worked in quarry industry?

(a) 5 years or less ☐

(b) 5-10yrs ☐

(c) 10 years or more ☐

8. What type of duties are you engaged in at the quarry or stone crushing industry?

(a) Stone Blustering ☐

(b) Machine Operator ☐

(c) Administration Work ☐
(d) Collection of stone from the Quarry ☐

(e) Loading section ☐

(f) Bagging section ☐

(g) Transportation section ☐

9. Are you

(a) Trained in your job ☐

(b) Untrained ☐

SECTION B: Assessment of Level of Awareness

10. What are occupational hazards associated with stone extraction (please tick appropriate box)

(a) Injury ☐

(b) Noise pollution ☐

(c) Inhalation of dust ☐

(d) Exposure to excess heat and possible ill-effect ☐

(e) Others

(Specify)…………………………………..

11. What protection measures do you adopt at work place?

(a) Wear Respirator ☐

(b) Wear Nose and Mouth Mask ☐

(c) Protective clothing ☐

(d) Others

(Specify) ....

12. Do you bath before leaving for home?

Yes	No

13. Do you change to clean clothes before going home?

Yes	No

14. Do you wash your hand before eating, snuff, or smoke?

YES	NO

15. Who provide you with the protective measures?

(a) Self ☐

(b) Employer ☐

16. Have you had any training or talk on occupational hazards of your job

YES	NO

B. SYMPTOMS

This section requires you to provide information mainly about your chest. I would like you to answer "YES" or "NO" whenever possible.

COUGH

17. Do you usually have a cough?

Y	N

18. Do you usually bring up any phlegm/sputum/mucus from your chest first thing in the morning (on getting up*) in the winter?

Y	N

19. Do you usually bring up any phlegm/sputum/mucus from your chest during the day (or at night*) in the winter?

Y	N

EPISODES OF COUGH AND PHLEGM

20. Have you had periods or episodes of (increased**) cough and phlegm lasting for 3 weeks or more each year?

Y	N

BREATHLESSNESS

21. Are you troubled by shortness of breath when hurrying on level ground?

Y	N

WHEEZING

22. Does your chest ever sound wheezy or whistling:

Y	N

IF YES TO 10

a. When you have a cold?

Y	N

b. Occaisonally apart from colds?

Y	N

c. Most days or nights?

Y	N

d. For how many years has this been present? _________ years

23. Have you ever had attacks of bronchitis:

Y	N

24. Have you ever had chronic bronchitis?

Y	N

25. Have you ever had emphysema?

Y	N

IF YES TO 13

a. Do you still have it?

Y	N

b. Was it confirmed by a doctor?

Y	N

26. Have you ever had asthma?

Y	N

IF YES TO 14:

a. Do you still have it?

Y	N

b. Was it confirmed by a doctor?

Y	N

c. At what age did it start? _______ Age in years

d. If you no longer have it, at what age did it stop? _______ Age stopped

27. Have you had chest tuberculosis?

Y	N

IF YES TO 27:

a. Do you still have it?

Y	N

b. Was it confirmed by a doctor?

Y	N

c. When did this happen? _________ Year

d. How long did you receive treatment for this _______Months

e. Did you have a second episode of TB?

Y	N

f. When did this happen? ________ year

g. How long did you receive treatment for this? ______ months

28. Have you ever had?

a. Any other chest illnesses as mentioned by a doctor?

Y	N

If yes, please specify ____

C. TOBACCO SMOKING

29. Have you ever smoked cigarettes?

Y	N

IF YES to 17:

a. Do you now smoke cigarettes (as of 1 month ago)?

Y	N

b. How old were you when you first started regular cigarette smoking? ____ Age

c. If you have stopped smoking cigarettes completely, how old were you when you stopped? ____ Age stopped

d. How many cigarettes do you smoke per day now? ___ Cigarettes/day

e. In the past, how many did you smoke per day? ___ Cigarettes/day

f. For how many years did you smoke this number? ___ years

g. Do or did you inhale the cigarette smoke?

1. Not at all ______
2. Slightly ________
3. Moderately ______
4. Deeply __________

h. During the years that you smoked, did you ever quit for a year or more?

Y	N

i. If yes, how long? _____________

E. OCCUPATIONAL HISTORY ON THE QUARRY

30. Please list in the table below any job that you held for more than one (1) year, which exposed you to dust.

JOB TITLE				JOB SITE			APPROX YEARS	
	Period of exposure	Year left work				OTHER	FROM	TO

F: Housing

31. How many years have you lived in your current house? ------------------ Years

32. Does your home have any of the following?

	Yes	No
central heating		
ducted air heating (forced air heating)		
air conditioning		

33. What kind of stove do you mostly use for cooking?

TICK ONE BOX ONLY

a) coal, coke or wood (solid fuel)	
b) gas (gas from the mains)	
c) electric	
d) paraffin (kerosene)	
e) microwave	
f) gas (gas from bottles or other non-mains source)6	
g) other	

THANK YOU FOR TAKING PART IN THIS STUDY.

APPENDIX E: CERTIFICATE OF PROOF READING

ACET Consultancy
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21 February 2019

To whom it may concern

LANGUAGE EDITING – SAIMA SHIHEPO

This letter serves to confirm that a Master of Health Sciences thesis entitled "Assessment of Dust Exposure and Risk of Chronic Respiratory Diseases Among Stone Corrie Quarry Workers in Namibia, 2018" by Saima Shihepo was submitted to me for language editing.

The thesis was professionally edited and track changes and suggestions were made in the document, which if followed by Ms Saima Shihepo will result in a thesis with a high standard of English.

Yours faithfully

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