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JOHANNESBURG

WORKER'S KNOWLEDGE AND PRACTICES ON FACTORS INFLUENCING THE RISK OF SILICA DUST EXPOSURE IN LESOTHO MINES

RESEARCH REPORT

by

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Submitted in partial fulfilment of the requirements for the degree.

Master of Science in Medicine: Exposure Science

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The African Union Development Agency - NEPAD

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Declaration

I, Vuyiseka Langwana (student number: 2759995), declare that the research project entitled *"*Worker's knowledge and practices on factors influencing the risk of silica dust exposure in Lesotho mines*"* is my research work undertaken under the supervision of Prof M.D Masekameni and Mr N.N Khoza. The work is being submitted in partial fulfilment for the degree of Master of Science in Medicine: Exposure Science in the Faculty of Health Sciences at the School of Public Health, University of the Witwatersrand, Johannesburg. This work has not been presented for examination at any other university. The Principal Investigator designed the study, carried out data analysis, and wrote the research report. The Principal Investigator declare collaboration with other co-authors during the course of the project. However, all the work carried out in collaboration was done by the Principal Investigator. Parts of this research report have been planned to be presented at conferences. Chapter 1 to 6 have been published or submitted in peer-reviewed journals. All the sources cited in this study have been acknowledged through comprehensive references. The plagiarism declaration is signed and attached as Appendix 1: Plagiarism Declaration Form.

Dedication

This study is dedicated to the Lord our Almighty for His grace and protection throughout this study. This research study is also dedicated to the management of the African Union Development Agency – New Partnership for Africa's Development (AUDA-NEPAD), particularly their quest for the inclusive and sustainable development of the African continent, as articulated by the African Union (AU) Agenda 2063: The Africa We Want, who kindly granted the Principal Investigator permission to use the primary study results, which was essential for this research study. I also dedicate this study to my loving family and friends, whose unwavering support and encouragement have been my source of strength throughout my research journey. This study is dedicated to all the individuals who have suffered silicosis as a result of excessive exposure to crystalline silica dust in Lesotho mines.

Publications

Publication 1

Langwana, V., Khoza, N.N., Rathebe, P. C., Mbonane, T. P., Masekameni, M. D. (2024). Knowledge, Attitudes, and Practices on Occupation Health and Safety Amongst Mine Workers Exposed to Crystalline Silica Dust in a Low-Income Country: A Case Study from Lesotho. *Safety*, *10*(3), 76. https://doi.org/10.3390/safety10030076.

Author Contribution

V and M.D drafted and conceptualised the project. V designed the study, carried out data analysis, and wrote the research report while M.D initiated the first draft of the paper. D.M and NN validated the methodology, data analysis and interpretation. V edited the draft before submission to D.M and NN. PC and TP did grammar checks and quality control. The project was supervised by D.M and NN.

Abstract

Background

Exposure to respirable crystalline silica (RCS) dust is a major occupational hazard linked to serious lung diseases, including silicosis, lung cancer, and pneumoconiosis, with mining accounting for a significant portion of these illnesses. Despite awareness of silica's health risks and efforts to control exposure, hazardous levels persist in industries like mining, quarrying, and mineral processing, where silica is found in materials such as quartzite, sandstone, and granite. Silicosis, an irreversible lung-scarring disease, remains prevalent among workers, particularly miners in Lesotho, where cases have slightly increased, underscoring the need for improved silica dust control measures. Although preventive controls exist, there is an urgent need to enhance silica exposure management in these high-risk environments.

Aim

This study aims to evaluate mine workers' knowledge, attitudes and practices regarding factors that increase the risk of silica dust exposure in selected mines in Lesotho.

Methods

The study employed a descriptive retrospective cross-sectional design with a quantitative approach. A record review guide was used to gather secondary data from the Southern Africa Tuberculosis and Health Systems Support (SATBHSS) project. This data was entered into Microsoft Excel, cleaned for accuracy, and analyzed in STATA software, version 17, using both descriptive and inferential statistics. The study focused on a sample of workers from 5 selected mines, chosen from 11 active mines in Lesotho, which extract various minerals. The selected mines were those engaged in mining diamonds, sandstone, and quarry materials. The study aimed to assess the knowledge, attitudes, and practices of mine workers regarding factors that elevate the risk of silica dust exposure in these mines.

Results

The study found that mine workers had good knowledge about certain Occupational Health and Safety (OHS) hazards, with high awareness of lung cancer (91%), noise levels (99%), and safety stressors (96%). However, 90% of workers lacked adequate knowledge on physical stressors in their workplaces. The average knowledge score was 13.43 (SD = 2.99), with scores ranging from 6 to 19 and a median of 14. Regarding preventive practices, 55% of workers reported the presence of health and safety strategies, 60% held regular safety meetings, and only 40% indicated regular dust and noise monitoring by employers. Additionally, 56% had health and safety representatives at work. Notably, 15% viewed the work as suitable only for the "brave," and 65% considered minor accidents a normal part of the job. The workforce was predominantly male (91%) with most having secondary education (79%), which may impact their understanding of training resources on crystalline silica exposure.

Conclusion

This study reveals that, while health and safety programs exist within mines to prevent exposure to respirable crystalline silica (RCS) dust, gaps in program implementation leave workers at risk for silicosis and other respiratory diseases. Mine workers generally had limited knowledge about managing RCS dust exposure, which leads to poor practices in dust control. The findings emphasize that engineering controls alone are insufficient, underscoring the need for a broader hierarchy of controls and improved administrative measures, including training and best practices. Only 46% of participants recognized air measurements as beneficial for controlling dust exposure. This study, the first of its kind in Lesotho, could inform national policies on silica dust exposure control. However, its findings may be less generalizable to similar mining contexts across Africa due to its retrospective, questionnaire-based design, which may introduce response bias. The study suggests that greater emphasis on knowledge, attitudes, and practices is essential to effectively reduce silica dust exposure in mines.

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Table of Contents

Declaration ii

Dedication iii

Publications iv

Abstract v

Acknowledgments vii

Funding viii

List of figures xiii

List of Tables xiv

List of abbreviations xvi

Definition of terms xviii

1. Background 1

1.1 Problem Statement 4

1.2 Research Question 5

1.3 Aim of the Research 5

1.4 Objectives: 5

1.5 Justification of the Research 5

2. Literature Review 7

2.1 Primary exposure pathways and determinants of silica dust exposure 7

2.2 Health effects associated with silica dust exposure 7

2.3 Overview of KAP studies regarding silica dust exposure in mining industries 8

3. Methodology 14

3.1 Study design 14

3.2 Study area 14

3.3 Study Population 17

3.4 Sampling 17

3.5 Data collection 18

3.5.1 Record Review Guide 19

3.5.2 Outcome variables 20

3.5. Data Processing and Management 21

3.6 Data Analysis 22

3.7 Reliability and Validity 22

3.8 Ethics 22

4. Results 24

4.1 Demographic characteristics 24

4.1.1 Knowledge of respirable crystalline silica dust among mine workers 30

4.1.2 Study participants' attitude 32

4.1.3 Practices linked to prevention and protection against respiratory crystalline silica dust 33

4.1.4 Factors that influence the practice related to respiratory silica dust prevention in the study 35

5. Discussion: Introduction 38
5.1 Demographics of Participants 38
5.2 Knowledge on silica dust exposure risk factors 38
5.3 Attitudes on silica dust exposure risk factors 39
5.4 Practices of mine workers on silica dust exposure prevention measures and controls 40
5.5 Factors that influence practices relating to silica dust exposure in the study 42
5.5.1 Age 42
5.5.2 Work Experience 42
5.5.3 Education level 43
5.6 Limitations of the study 44
5.7 Strengths of the study 44
5.8 Recommendations 44
6. Conclusion 47
References 48
7. Appendices 59
7.1 Appendix 1: Plagiarism declaration form 59
7.2 Appendix 2: Turnitin report 60
7.3 Appendix 3: Similarity Index Letter 61
7.4 Appendix 4: AUDA-NEPAD Permission to nest the study into the bigger research study 62
7.5 Appendix 5: Research ethics clearance certificate 63

7.6 Appendix 6: Questionnaire on Knowledge, attitudes and practices of the participants..... 64

List of figures

Figure 1. Map of Lesotho. Source: (Lebina *et al*., 2016) 15

Figure 2: Health districts with the highest number of mine workers. Source: (Lebina et al., 2016). 16

Figure 3: Lesotho mine worker's population per health district. Source: (Lebina *et al*., 2016). 17

Figure 4**:** Demographic information of the participants. 25

Figure 5: Age of Participants 26

Figure 6: Level of education of the study participants. 27

Figure 7: Miner's Job titles. 28

Figure 8: Mine worker's experience. 29

Figure 9: Primary commodities. 30

Figure 10: Participants knowledge response on respirable crystalline silica dust. 31

Figure 11: Workers' attitude response on factors or conditions leading to dust exposure. . 32

List of Tables

Table 1:Questions on the study participants' knowledge..... 20

Table 2: Questions on the practices related to respirable crystalline silica dust. 21

Table 3 : Participants responses on the practices related to respirable crystalline silica dust exposure..... 33

Table 4: Bivariate regression analysis of socio-demographics influencing the practice score. 35

Table 5: Bivariate regression analysis of knowledge and attitude influencing the practice score..... 36

Table 6: multivariate linear regression shows factors influencing the practice in the study. 37

List of abbreviations

AU	African Union
AUDA-NEPAD	African Union Development Agency – New Partnership for Africa's Development
H&S	Health and Safety
HIV	Human Immunodeficiency Virus
IARC	International Agency for Research on Cancer
ILO	International Labour Organisation
NEPAD	New Partnership for Africa's Development
NIOSH	The National Institute for Occupational Safety and Health
OHS	Occupational Health and Safety
OHSA	Occupational Health and Safety Act
PEL	Permissible Exposure Level
PPE	Personal Protective Equipment
RCS	Respirable Crystalline Silica
SADC	Southern African Development Community
SATBHSS	Southern Africa Tuberculosis and Health Systems Support
TB	Tuberculosis

WHO	World Health Organisation

Definition of terms

Inhalable dust

The particulate mass fraction of dust in the work environment that can be inhaled and deposited anywhere in the respiratory tract (particles smaller than 50 µm in aerodynamic diameter)

Mining

Mining is the process of extracting valuable minerals or other geological materials from the ground or sea, usually from an orebody, lobe, vein, seam, reef, or place deposit that has economic value.

Respirable crystalline silica (RCS)

That portion of airborne crystalline silica that is capable of entering the gas-exchange region of the lungs when inhaled (less than 10 microns)

Silicosis

Silicosis is a form of pneumoconiosis and an occupational disabling, non-reversible and sometimes fatal respirable disease caused by the inhalation of dust that contains free crystalline silica (RCS)

CHAPTER ONE

This chapter begins with an overview of respirable crystalline silica (RCS) dust exposure, its sources across various mining industries, and its health effects on workers. It further describes the different types of rocks associated with silica dust exposure. The problem statement, the research question, the study aim, and the objectives of the study are outlined, and the chapter ends by presenting the justification of the study.

1. Background

Exposure to respirable crystalline silica dust is one of the most common and severe risks due to the associated health outcomes among workers. There is sufficient scientific evidence indicating that extended exposure to crystalline silica dust contributes to the development of silicosis and active Tuberculosis (Sifanu *et al*., 2023). Respirable crystalline silica is among the most common factors detrimental to workers' health in occupational environments, particularly in the mining industry. Silicon dioxide (SiO2), sometimes referred to as silica, is one of the most abundant chemical substances in the world (Maciejewska, 2014). Silica (SiO_2) is the second most abundant compound in the Earth's crust. It can be found in sand, rock, and soil (Möhner, Pohrt and Gellissen, 2017). Exposure to respirable crystalline silica dust occurs in many industries including mining, quarrying and mineral processing amongst others (Möhner, Pohrt and Gellissen, 2017). Respirable crystalline silica dust is produced when rock containing silica is crushed, drilled or blasted (Boudigaard *et al*., 2021). Basically, where concrete, stone or sand-based materials are used there is a potential for exposure to crystalline silica dust.

Common rocks containing respirable crystalline silica in varying amounts, include quartzite, sandstone, shale, and granite. Quartz is the most common type of naturally occurring respirable crystalline silica, and because it is ubiquitous, there is a high potential for occupational exposure to RCS for workers in mining (Couture *et al*., 2023). It makes up 12% of the Earth's crust and found in almost all types of rocks (Maciejewska, 2014). Respirable crystalline silica dust is made up of sharp, imperceptibly small breathable (respirable) particles that the naked eye cannot see. Silica dust causes increasingly severe- scarring and the formation of nodules inside the lungs. This damage is characteristic of silicosis and can be detected on X-ray before symptoms emerge (Khoza *et al*., 2012).

The primary pathway of silica dust into the human body is through the respirable organs; the exposure through skin or digestive tract is negligible. Crystalline silica dust exposure is mainly known for its association with lung diseases, most notably silicosis (Möhner, Pohrt and Gellissen, 2017). Depending on the total amount of respirable crystalline silica inhaled, a worker may develop acute, accelerated, or chronic silicosis. Exposure to respirable crystalline silica is the primary cause of silicosis, which is typically a nodular pulmonary fibrosis (Omidianidost *et al.*, 2015). Silicosis is a progressive and non-reversible lung-scarring disease in humans exposed to silica dust (Hoy *et al.*, 2022). Despite being an incurable and irreversible condition, silicosis is mostly preventable by limiting workers' exposures to respirable silica dust. It is currently a major significant public health concern as a risk factor for pulmonary tuberculosis (Chen, Liu and Xie, 2022) and one of the most important health problems in the world because of its potential to cause physical disability. The damage brought on by exposure to respirable crystalline silica dust typically takes time to manifest (has a long latency period), and it may take years for symptoms to develop (Misra *et al.*, 2023). However, Silicosis can occasionally progress quickly when dust exposure levels are high (McLean, Glass and Douwes, 2017). It is typical for mineworkers to retire without knowing that they have silicosis and for the symptoms to emerge and become progressively worse in their retirement years. The disease's severity depends on the dust type, concentration, exposure duration, and individual susceptibility. The world approach to eliminating silicosis is focused on controlling exposure to silica dust (Khoza *et al.*, 2012).

Exposure to respirable crystalline silica dust results in many occupational lung diseases, such as silicosis, cancer, and pneumoconiosis (Park *et al.*, 2019; Blagrove-Hall *et al.*, 2021). Thus, the International Agency for Research on Cancer (IARC) classified respirable crystalline silica dust as a Group 1 carcinogen. This classification stems from the fact that exposure to high levels of respirable crystalline silica dust for prolonged periods may result to carcinogenic adverse health effects such as lung cancer (Pelucchi *et al.*, 2006). Chronic occupational exposure to respirable crystalline silica can also result in non-malignant adverse health effects, including tuberculosis/ silicotuberculosis, emphysema, small airways disease, chronic obstructive pulmonary disease, chronic bronchitis and pulmonary silicosis (Milovanović *et al.*, 2011), autoimmune diseases (rheumatoid arthritis, scleroderma, systemic lupus erythematosus) and kidney disease (Vupputuri *et al.*, 2012), while it has been demonstrated that acute occupational exposures to high concentrations of crystalline silica

can cause shortness of breath, cough and pulmonary alveolar lipoproteinosis (Andraos, Utembe and Gulumian, 2018).

Mining is considered one of the most predisposed industries in the world for diseases and injuries (Sifanu et al., 2023). This is primarily due to the fact that mining activities involve extracting minerals from the earth's crust, which exposes workers to mineral dust, including respirable crystalline silica (Sifanu et al., 2023.). Globally, mining accounts for a significant percentage of both fatal and non-fatal occupational injuries. In addition to mining, industries such as construction, sand- blasting, foundry work and agriculture, amongst others, continue to record losses and inefficiencies of productivity and quality control worldwide because of non-compliance, regardless of workers familiarity with occupational health and safety (OHS) concepts (Cagno *et al.*, 2014). A study conducted by Francis et al., (2021), has demonstrated that exposure to respirable crystalline silica remains one of the detrimental concerns associated with mining. Consequently, considerable efforts have been made by the World Health Organization (WHO) and the International Labour Organization (ILO) to prevent silicosis; However, the number of cases reported in the mining sector is still high (Sifanu et al., 2023). Furthermore, a study conducted by Ngosa & Naidoo, (2016) , reported that there has been a notable increase in respirable dust exposure in the mining sector.

The mining industry accounts for a significant proportion of respirable-related illnesses (Sifanu et al., 2023). However, it receives less attention (Muneku & Naidoo et al., 2015). According to another study by Sifanu et al., (2023.), mining continues to be one of the most hazardous industries in the world, and this is owing to the fact that, the majority of mine workers, especially in Southern Africa, work in poorly respirable dust-controlled environments; where exposure to high levels of RCS increases their risk of developing silicosis and TB. The mining industry creates jobs and contributes to the economic growth of the SADC region. This carries a heavy burden due to the high incidence of TB (World Health Organization, 2019); the fact that their main occupation entails crushing rocks containing silica makes this a burdensome situation. Poor working conditions in mining sites, such as prolonged exposure to respirable crystalline silica dust, inadequate ventilation, and insufficient hazard control, are blamed for the problem. The situation is exacerbated by a lack of knowledge to understand the occupational exposure to respirable crystalline silica dust well and implement appropriate control measures. The rapid economic and industrial

development, and the high demand for coal energy and metal material have resulted in more people being exposed to RCS in the mining industry. This rapid increase shows how rapid changes in industrial processes require constant maintenance and vigilance to identify and control potential sources of RCS exposure (Hoy *et al*., 2022).

1.1 Problem Statement

Respirable Crystalline Silica exposure remains a significant public health issue. It continues to be among the most lethal of occupational risks and is a major public health challenge worldwide (McLean, Glass and Douwes, 2017). Despite the cause of silicosis being unquestionable, countless workers across the globe persistently face dangerous levels of RCS exposure (Hoy et al., 2022; Si *et al*., 2016).

Exposure to respirable crystalline silica dust is one of the most common occupational risks among miners in Lesotho mines (Wits Health Consortium, 2017). The prevalence of silicosis among miners in Lesotho increased from 26.6% to 27% annually. Prevention efforts have been taken to reduce silica exposure for many decades, such as the development and implementation of some controls (Shi *et al*., 2020). However, despite silica exposure controls being put in place in Lesotho mines and progress in technological developments to control, there is still an urgent need to manage silica exposure in this country efficiently (Hall *et al*., 2022; Hoy et al., 2022). In addition, although it is apparent that silica exposure at high levels is potentially hazardous, little is known about the risk factors that influence exposure to silica (Ge *et al*., 2020), and measures that only focus on the technical element are insufficient to address the issues of worker health promotion (Bloch *et al*., 2018).

People tend to be ignorant when they lack detailed knowledge, as they cannot anticipate the risk that exposure poses, making them susceptible to diseases.

Lack of awareness, education, and knowledge studies regarding this population's exposure to respirable crystalline silica dust has led to this. Therefore, to understand the problem at hand, there is a need to evaluate the knowledge, attitudes and practices of mine workers on factors that increase the risk of silica dust exposure in selected mines in Lesotho. This study aims to assess the knowledge, attitudes and practices of silica dust exposure risk factors among mine workers and their practices on silica dust exposure prevention measures.

1.2 Research Question

What are the knowledge, attitudes, and practices of mine workers regarding factors that increase the risk of silica dust exposure in selected mines in Lesotho?

1.3 Aim of the Research

This study aims to evaluate mine workers' knowledge, attitudes and practices regarding factors that increase the risk of silica dust exposure in selected mines in Lesotho.

1.4 Objectives:

- To assess the knowledge and attitudes on silica dust exposure risk factors amongst mine workers in Lesotho;
- To assess the practice of mine workers on silica dust exposure prevention measures and controls;
- To determine factors that influence practices relating to silica exposure dust in the study population.

1.5 Justification of the Research

Mine workers are currently recognized as one of the most exposed groups to respirable crystalline silica due to the nature of their work (Sifanu *et al*.,2023). According to another study by Sifanu *et al*., (2024), mining industry is one of the most hazardous industries in the services sector. Despite the fact that mine workers are more susceptible to contract silicosis than workers in other industries, this industry has received less attention (Zimba *et al*., 2019). Furthermore, a study conducted by Rahimi *et al*., (2023), reported that the prevalence of respiratory diseases among mine workers remains high, despite significant efforts to reduce dust exposure through lower permissible exposure limits (PEL) and improved monitoring methods.

Environments such as mining, require that workers are well educated about exposure to respirable silica dust (Sifanu *et al*., 2023). The rationale behind the educational program lies in that workers' knowledge gained is perceived to facilitate a shift in their 'attitudes' and 'work practices' as well as ensuring strict adherence to health and safety standards. In

developing countries, workers are exposed to silica dust due to poor working conditions in mining industries. A study conducted by Thuhuyen *et al*., (2023), stressed that a considerable proportion of individuals employed in the mining sector and exposed to silica remain uninformed about the potential human health risks associated with silica dust exposure.

The present study investigated mine workers' knowledge, attitudes and work practices on factors influencing the risk of silica dust exposure. In the literature, miners' susceptibility and mortality resulting from respirable dust exposure have been extensively documented (Moyo *et al*., 2023; Sifanu *et al*., 2023). However, there is limited scientific evidence available to comprehend the knowledge, attitudes, and practices of employees in relation to exposure to respirable dust (Sifanu *et al*., 2023). Therefore, this study focused on one aspect of exposure control, where it looked at the use of knowledge to change workers' perceptions and to promote good practices that support all workplace exposure controls. This will help to improve mine workers' knowledge of silica exposure risk to prevent the development of silicosis. The study will enhance understanding of knowledge, attitudes and practices of risk factors that influence respirable crystalline silica exposure among mine workers in Lesotho. The findings will assist policymakers in developing targeted interventions to reduce the prevalence of silicosis in Lesotho mines.

CHAPTER TWO

This chapter reviews the literature related to crystalline silica dust exposure to establish the link between this study and what has already been studied. This chapter begins with identifying the primary exposure pathway of silica dust from the source to the exposed receptor and describes the important determinants of the severity of silicosis, such as the type of dust, concentration, duration of exposure, and the individual's susceptibility. The chapter further discusses the health effects associated with crystalline silica dust exposure and ends with the discussion of knowledge, attitudes, and practices as important components of exposure controls that support engineering control strategies.

2. Literature Review

2.1 Primary exposure pathways and determinants of silica dust exposure

According to Chen *et al*. (2022), inhalation is the primary route of exposure to crystalline silica dust. The lungs are the primary focus for the uptake of crystalline dust inhalation from occupational or environmental components (David *et al*., 2006; Chen *et al*., 2022). The effects of silica dust exposure take years to manifest, and the disease typically develops gradually. However, high levels of silica dust exposure are associated with a short incubation period and rapid disease progression (OSHA, 2017). The type of the dust, concentration, the duration of exposure, and the individual's susceptibility to the disease determine the severity of the condition (Khoza *et al*., 2012).

2.2 Health effects associated with silica dust exposure

Generally, silicosis results in progressive and almost fatal conditions from the beginning of inflammation and fibrosis (Rahimi *et al*., 2023). Once silicosis develops in the human body, several respiratory symptoms emerge, such as a dry, persistent cough that is frequently accompanied by fatigue, weight loss, sputum expectoration, shortness of breath, and chest tightness (Borm, Fowler and Kirkland, 2018). This could even have worse complications, such as tuberculosis, respiratory tract infection, and respiratory insufficiency, appear (Chen, Liu and Xie, 2022). These symptoms may become so crippling, making it impossible for the individual to perform basic tasks of daily living. Cancer and heart failure may arise from the

disease. Additionally, it compromises the immune system, making people much more prone to acquiring active TB and increasing the probability of TB being fatal (Knight *et al*., 2020). Therefore, this implies that silica dust exposure is an important global public health concern.

2.3 Overview of KAP studies regarding silica dust exposure in mining industries

Around the world, respirable crystalline silica dust exposure affects more than 23 million, 3.2 million, and 2 million workers in China, Europe, and the United States, respectively (Requena-Mullor *et al.*, 2021). There were over 20,000 incident cases of silicosis reported in 2017 and millions of workers are still exposed to Respirable Crystalline Silica dust. Due to deficiencies in reporting systems and occupational respiratory health surveillance programmes across many countries, the number of identified cases is significantly underestimated. Workers who lack knowledge regarding silica dust exposure are more vulnerable to increased exposure to RCS (Hoy *et al.*, 2022). Exposure to silica dust has become one of the most common occupational risks among workers in different industries, including construction, quarrying, and stone-crushing (Chaiear *et al*., 2018; Muneku & Naidoo *et al*., 2015). However, in terms of the number of cases of respiratory-related illness, globally, the mining industry dominates the field (Sifanu *et al*., 2023). According to a study by TIMS. (2018), there is still a debate about precisely what mining operations pose the most significant risk of silica exposure. However, according to a study by Lebina *et al*. (2016), high rates of silicosis among gold mine workers. In developing countries in Africa, Asia, the Middle East and South America, silica exposure dust has caused the greatest morbidity and mortality (Hoy *et al*., 2022). Globally, millions of workers continue to be exposed to RCS with 20 000 people infected by silicosis, while there are over 12.9 thousand deaths annually (Chen *et al*., 2022; Hoy *et al*., 2022). Additionally, the burden of silicosis is considered to be among the vast population of miners and ex-miners in Southern Africa and it has been widely acknowledged as a public health crisis. Main contributors to the co-epidemic include mining industry-related factors such as silica dust inhalation, transmission in congregate settings, and migration (Bloch *et al.*, 2018).

The mining sector plays a crucial role in enhancing the economic wealth of many countries. This noteworthy impact on mining economies has frequently been at the expense of the well-being of individuals employed within the mining sector (Sifanu *et al*., 2023). Measures for

controlling dust are implemented to minimize exposure to dust particles, and the efficiency of these strategies relies on the extent to which workers use them, which is influenced by their level of knowledge, attitude, and practices.

Furthermore, according to World Health Organization, (2019), the mining industry creates jobs and contributes to the economic growth of the SADC region. However, this carries a heavy burden due to the high incidence of TB, and this situation is exacerbated by the fact that their primary occupation involves crushing rocks that contain silica. Increased respirable crystalline silica exposure is attributed to poor working conditions in mining sites, such as extended exposure to respirable dust, insufficient ventilation, and inadequate hazard control. Insufficient knowledge to understand occupational exposure to silica dust well and implement effective control measures exacerbates the situation (Hoy *et al*., 2022).

Mining operations expose workers to crystalline silica dust, which has contributed significantly to tuberculosis outbreaks in southern Africa and other low-income areas across the globe (Ngosa and Naidoo, 2016). Workers who are involved in mining activities such as drilling, crushing of rocks and tipping are more susceptible to develop silicosis, due to their excessive exposure to respirable crystalline silica dust. Unfortunately, the majority of mine workers in southern Africa operate in uncontrolled settings, where excessive exposure to RCS increases the risk of contracting silicosis and Tuberculosis (Sifanu *et al.*, 2024). Lesotho is noted for its mineral wealth, particularly diamond, and the mining industry contributes more than 50% of the country's foreign earnings. More than 73 000 people are employed in the Lesotho mining industry (Wilson *et al*., 2015). According to Ngosa & Naidoo, (2016)**,** several researchers have noted increased TB prevalence with more prolonged exposure duration.

Mining is considered one of the world's most predisposed environments for occupational diseases and injuries. The mining industry has recorded significant silicosis cases worldwide (Sifanu *et al*., 2023). According to a study by Hoy *et al*., (2022). the mining industry has received a lot of attention from researchers and preventative initiatives, whereas many other occupational settings with hazardous RCS exposure receive less attention, particularly the construction industry. However, this study is in contradiction with many previously published studies. A study by Zimba *et al*., (2019) , claimed that, even though mine workers

are more susceptible to contract silicosis than workers in other industries, this industry has received less attention. In addition, a study by Sayler *et al*., (2018) reported that silica dust exposure is highly prevalent in the mining industry. furthermore, according to a study conducted by Rahimi *et al*., (2023), the prevalence of respiratory diseases among mine workers remains high despite significant efforts to reduce dust exposure through lower permissible exposure limits (PEL) and improved monitoring methods. According to Sifanu *et al*., (2023), many countries' regulatory bodies have developed exposure limits aimed at protecting workers from the harmful effects of exposure to RCS. However, because these limits only set the maximum amount of RCS to which workers may be exposed for a set amount of time (eight hours), they are insufficient to control exposure to silica dust.

Despite the paucity of information on silicosis in southern African mining industries, the studies that have been done suggest that millions of people in this region are exposed to silica dust, with Lesotho mine workers bearing most of the risk (Lebina *et al*., 2016). Additionally, Kim *et al*., (2021) stated that, in spite of the rise in the number of cases among mine workers in Southern Africa, respirable diseases such as silicosis and lung cancer, as a result of exposure to respirable crystalline silica dust have not been adequately investigated. Another study by Sifanu *et al*., (2024) also concurred that there has not been enough research done on diseases induced by exposure to crystalline silica dust. Materials extracted in numerous mining operations contain a high concentration of silica. Research studies continue to help reduce the levels of respirable silica dust to which mine workers are regularly exposed; however, few research studies have been done to protect mine worker's health further (Haas *et al*., 2016). To date, Interventions have concentrated on the development and implementation of engineering control technologies in an effort to prevent silicosis and other diseases linked to silica dust exposure (Cauda, Miller and Drake, 2016). Although the engineering control technologies greatly reduce exposure, majority of mine workers are still overexposed, prompting the need to incorporate behavioural study components into the developed technologies to further alleviate mine workers' overexposure to respirable crystalline silica dust (Haas *et al*., 2016).

The mining sector contributes significantly to the economic success of many countries. However, the substantial economic benefit that mining has provided has often been at the expense of mine workers' health. The success of dust control measures, which are intended

to minimize dust exposure, depends on how well employees utilize them, which is greatly influenced by their knowledge, attitudes, and practices (Sifanu *et al*., 2023.). A study by Bui *et al*., (2020.) demonstrated that knowledge, attitudes and practices correlate with high levels of health education and further indicated that health education needs to be prioritized for mine workers to enhance their knowledge of factors influencing silica dust exposure. Furthermore, You *et al*., (2019) conducted a study on the knowledge, attitudes and practices of mine workers in relation to occupational health and safety and the results revealed that mine workers showed a lack of knowledge and understanding of health and safety regulations and, thus, demonstrated insufficient knowledge of occupational diseases, which impact their practices. A study by Y. Kim *et al*., (2016) added that, a lack of knowledge plays a role in influencing unsafe behaviours among mine workers. Additionally, a study conducted by Francis *et al*., (2021) found that in the available literature, there is still a dearth of research on workers' knowledge regarding the adverse health effects of crystalline silica dust exposure, especially in developing countries.

The prevalence of silicosis continues to rise unabated across the Southern African Development Countries (SADC) region. According to a study by Wits Health Consortium. (2017) ,The following data reflects annual growth rates in several countries in the SADC region: The top country was Lesotho (26%), having former miners who had worked in South African gold mines, followed by Zambia (22%). However, Zimbabwe measured a rate of 0.1% increase, raising doubts about the reliability of these findings. This could be attributed to this region's lack of awareness about silicosis. According to Maboso *et al*. (2023), there has been an increase in knowledge of silicosis in miners from the early twentieth century. However, contrary findings from research studies indicate that there is still a lack of knowledge regarding silica dust exposure, particularly in the SADC region (Sifanu *et al*., 2023). A study by Wits Health Consortium. (2017) also revealed that workers' knowledge, attitude and practices towards silicosis is not well established compared to diseases such as TB, HIV, and AIDS. Additionally, only 19% of respondents in Lesotho said they had heard of silicosis. Although efforts have been undertaken for several decades, there is still no effective treatment for silicosis except from lung transplantation, which is provided to a small percentage of patients (Chen *et al*., 2022).

A study by Sayler *et al*., (2018) posited that although monitoring silica dust is an expensive task that can be particularly challenging in low-resource settings, knowledge and understanding of exposure are essential to safeguarding workers' health. Francis *et al*., (2021) defined awareness as having knowledge and understanding that a particular situation or fact exists. Regrettably, many workers exposed to silica dust, particularly in underdeveloped countries, are typically uninformed or lack knowledge of the potential health risks that silica dust exposure may pose to humans (Kabir, Islam and Taufikuzzaman, 2018). Research studies conducted by Gottesfeld *et al*., (2019) and Kabir *et al*., (2018) suggests that Increasing workers' knowledge of the detrimental health impacts of silica dust exposure can reduce the risks to their health. This is in accordance with a study conducted by (Momani, Hirzallah and Mumani, 2016). which also revealed that improving worker's knowledge of occupational exposures such as crystalline silica dust may significantly influence workplace health and safety behaviour. One of the most efficient strategies to help lower exposure is to increase knowledge about the risks to human health and safety posed by silica dust (Sharma *et al*., 2016). Unfortunately, in contrast to the developed world, not much research has been done on knowledge regarding the human health risks associated with silica dust in developing countries (Falk *et al*., 2019; Nandi *et al*., 2018). Workers who know the adverse health impacts of silica are more cognizant of the risks associated with silica dust inhalation and the preventative actions that can be taken (Momani, Hirzallah and Mumani, 2016). Therefore, it is critical that all workers who are exposed to silica dust have adequate knowledge and understanding of the potential health risks associated with it.

According to a study by Moyo *et al*., (2023) , silicosis is a progressive disease with over thirty percent of the cases progressing despite removal from silica dust exposure. Improving mining practices requires education and adequate knowledge about the associated occupational exposures. A study by Dixit *et al*.,(2023), found that silicosis continues to be a significant health risk among workers having occupational exposure to crystalline silica dust; and although there are numerous studies covering its clinical presentations, radiological aspects, pulmonary functional derangement, and associated complications; very little is known about the sociodemographic profile, working habits, knowledge, and practices about the disease and as well as other factors among workers engaged in occupations associated with the risk of silicosis. This study also revealed that the mining industry is characterized by male domination, low literacy, long work hours over an extended period of time, bad

work practices, and a lack of knowledge regarding silica dust exposure, as well as the ineffective personal protection clothing at work. Another study by Haas *et al*., (2016) found that, despite the widespread discussion and advocacy in the literature for an empirical approach to intervention planning that incorporates formative research to help identify what internal (knowledge, attitudes, and practices) and external (environmental) factors are present; there are only a few studies that discuss these processes in actual practice. It has been noted that unsafe work practices, such as working without respiratory protection equipment, among miners engaged in dusty operations, raise the risk of respirable silica dust exposure (Sifanu *et al*., 2023).

Some work situations, such as mining environments, require workers to be educated regarding exposure to respirable dust. The rationale behind the educational program is that the workers' knowledge gained is perceived to help them change their attitudes and work practices as well as seriously adhering to health and safety standards. However, it is noted that mine workers in developing countries bear the brunt the most on health implications due to continuous exposure to silica dust as a result of unfavourable working conditions (Sifanu *et al*., 2023). A study by Bui *et al*., (2020) emphasized that many of the silica-exposed workers in the mining industry are not well-trained and educated about the detrimental effects that silica dust exposure poses to human health.

Although respirable crystalline silica has long been known to have detrimental effects, a research study evaluating workers' knowledge, attitudes and practices on factors influencing crystalline silica exposure is still necessary as an effort to minimize the health effects of exposure to these factors (Maciejewska, 2014).Therefore, this study is designed to evaluate these factors among mine workers in an effort to improve mine workers' knowledge, attitudes, and practices regarding silica exposure risk to prevent silicosis, inform interventions aimed at combating this deadly disease, and thus prolong the lives of those who are susceptible to silicosis.

CHAPTER THREE

This chapter provides a layout of the methodology that was followed in this study. The primary data was collected using a questionnaire-based survey to collect data for the main study by the Southern Africa Tuberculosis Health Systems Support (SATBHSS) project, which is a multi-country initiative aimed at combating tuberculosis and occupational lung diseases in mines, including those caused by exposure to respirable crystalline silica dust. This chapter concludes with the ethical considerations of the study.

3. Methodology

3.1 Study design

Main study:

The main study administered a questionnaire-based survey on demographics, KAP, and dust exposure measurements at five mine sites. Workers who were accessible to the researchers were randomly selected to participate in both the survey and dust sampling. Furthermore, a desktop review and interviews of key focal people were carried out at the identified mines in Lesotho.

Current study:

The study used a descriptive retrospective cross-sectional study design with a quantitative method. It employed secondary data from the Southern Africa Tuberculosis and Health Systems Support (SATBHSS) project.

3.2 Study area

Main study:

The study was conducted in Lesotho mines and within 11 active mines across the country, mining various minerals. The targeted mines were those that mined the three commodities diamonds, sandstone, and quarries. The five mining sites were selected, comprising two large diamond mines located in the Botha-Bothe and Mokhotlong districts, one medium-sized sandstone mine located in the Berea district and two quarry mines in the Maseru district, of

which one was a medium size located in Ha Tsiame/ Likotsi and the other a small-scale mine located in Ha Morija. These particular districts were selected because they have the highest reported prevalence of tuberculosis in Lesotho (Lebina *et al*., 2016).

Figure 1 illustrates the locations of health and welfare services in each of Lesotho's 10 districts. The red square blocks depict the locations of health services, which are responsible for directing health and social welfare services in each of Lesotho's 10 districts, as well as the distribution of mines around the country. However, residents in the Lesotho highlands struggle through harsh weather conditions and mountainous terrain, walking for an average of four hours, to seek medical care; without adequate staff and resources, resulting in doctors struggling to cope (Lebina *et al*., 2016).



Figure 1. Map of Lesotho. Source: (Lebina *et al*., 2016)

All four of the Lesotho districts with the highest number of miners bordered the Free State Province in South Africa, which historically had extensive gold mining and provided easy employment opportunities for Basotho. ***Figure 2*** below depicts the four districts with the highest number of miners.



Figure 2: Health districts with the highest number of mine workers. Source: (Lebina et al., 2016).

The distribution of former and current mine worker's population across various health districts in Lesotho is illustrated in ***Figure 3***, demonstrating a notable concentration in districts such as Maseru, Mohale's Hoek, Mafeteng, Leribe, and Berea. These districts host a significant portion of the mining workforce, reflecting the historical importance of mining activities in these areas. This provides valuable insights into the spatial dynamics of the mining labor force and indicates areas where health interventions are offered in Lesotho.

The prominence of Maseru, Mohale's Hoek, Mafeteng, Leribe and Berea districts in hosting former and current mine workers underscores the socioeconomic significance of mining in Lesotho.

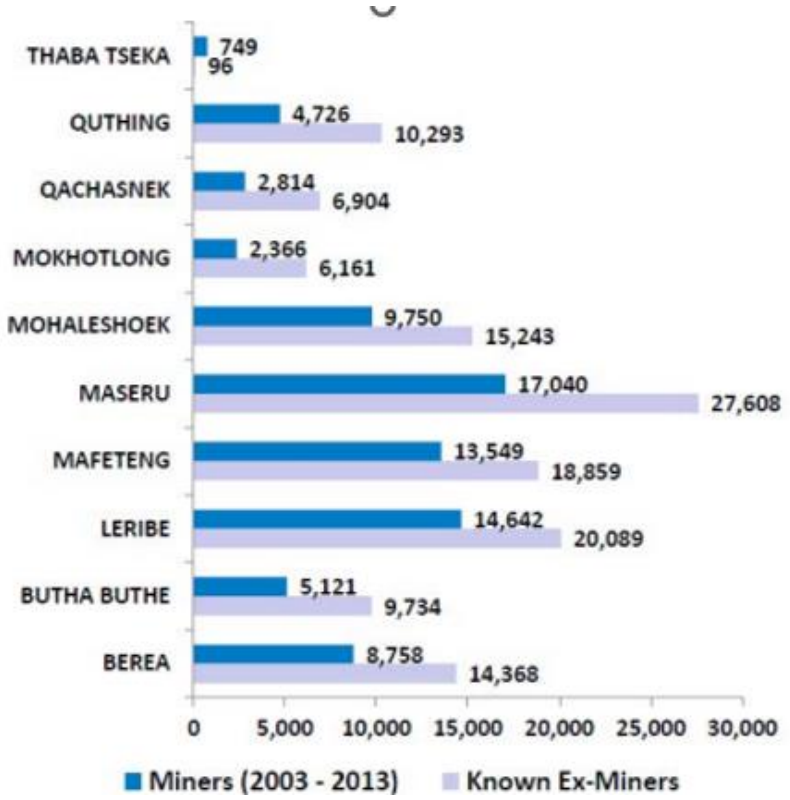

Figure 3: Lesotho mine worker's population per health district. Source: (Lebina *et al*., 2016).

3.3 Study Population

The study population included mine workers from the five selected mines in Lesotho. The study targeted mine workers who are exposed to respirable crystalline silica dust during mining operations.

3.4 Sampling

Main study:

The study purposefully identified and selected five mines (two large [diamonds], one medium [sandstone] and two small mines [quarries]). Furthermore, to select study participants purposive sampling approach was used to ensure that only those who were exposed to respirable crystalline silica were invited and participated in the study. According to Mensah & Naidoo, (2011), in 2007 there was an estimated of 53 467 miners in Lesotho. Epi Info was used to determine the sample size using the formula below. The population size was set as 53 467, the

anticipated frequency was set at 50% (because of the unknown prevalence of knowledge frequency), the precision was 5% and the design effect of 1.0. Therefore, the study sample size was 385 participants. This number represents a group of employees who experience RCS exposures similar enough that monitoring the RCS exposure of any worker in the group provides useful data, representing exposure of the rest of workforce doing similar activities, see more details in the calculation below.

Sample size (n) = [DEFF*Np(1-p)]/ [(d2/Z21-α/2*(N-1) +p*(1-p)]

N = population (53 467)

p = prevalence of poor knowledge (50%/0.5)

d = precision (5%/0.05)

DEFF = design effect (1.0)

Z1−α/2 = 1.96

Current Study:

No sampling was conducted in the current study, which is nested within a more extensive research project called the SATBHSS project.

3.5 Data collection

Main study:

The primary data was collected using a questionnaire-based survey to collect data for the main study by SATBHSS. The questionnaire in the main study was designed using existing literature and using expert advice. Furthermore, the study question's validity and reliability were checked by piloting prior the actual study. The questionnaires were translated into Sesotho, a local language, by a professional transcriber.

Current Study:

In the current study, secondary data was used, with records from 2019-2021 and a record review guide employed to collect data on participants' socio-demographics, knowledge, attitude, and practices related to occupational health and safety among respirable crystalline silica dust-exposed mines. The secondary data was retrieved, cleaned, and coded.

3.5.1 Record Review Guide

Main Study:

The primary data was collected using a structured questionnaire-based survey to collect data for the main study by SATBHSS project. The questionnaire in the main study was designed using existing literature and using expert advice. Furthermore, the study question's validity and reliability were checked by piloting before the actual study.

Current Study:

For the current study, secondary data was used, where records from 2019-2021 and a record review guide was used to collect data on participants' socio-demographics, knowledge, attitudes and practices related to crystalline silica dust-exposed mines. The secondary data was retrieved, cleaned and coded by the Principal Investigator.

The record review was used to collect the following socio-demographic factors: age (21-30 years=1, 31-40 years=2, 41-50 years=3, 51-50 years=4 & 61 years or older=5), educational level (high school=1, diploma=2, undergraduate degree=3 & postgraduate=4), gender (male=0 female=1), marital status (single=1, married=2 & widowed=3), job title (driver=1, general worker=2, plant operators=3, supervisor=4 & technicians) years working in the mine (1-10 years, 11-20 years & 21 years or more) primary commodities (diamond=1, sand stones=2 & dolerite=3). The sections on knowledge had 14 questions with a (no=0/yes=1) answer. The yes answer was deemed correct and a mark of 1 was allocated for every correct answer to calculate the knowledge score (ranging from 0 -15). The questions that were used in the main study on knowledge are listed in ***Table 1***.

Table 1:Questions on the study participants' knowledge

1. Are you trained on health and safety policy
2. Do you know and understand company Health and safety policies
3. Are you trained on Occupational Health Safety hazards
4. Does exposure to respirable crystalline silica cause lung cancer
5. Do you know the risk associated with high temperature
6. Do you know the risk associated with carbon monoxide poisoning
7. Do you know the risk associated with nervous system problems
8. Do you know the risk associated with hand-arm vibration
9. Do you know the risk associated with causes of silicosis
10. Do you know the risk associated with high noise exposure
11. Do you know the risk associated with chemical stressor
12. Do you know the risk associated with biological agents
13. Do you know the risk associated with physical stressors
14. Do you know the risk associated with safety stressors

The main study collected data on the study participants' attitudes towards exposure, health issues, safety and controls related to silica dust. The attitude questions had two responses, it was either disagree (coded as 0) or agree (coded as 1). The participants were asked if they disagreed or agreed with the following statements in the main study: i) I think our work is meant for the brave and not for people who are worried about H & S? ii) i consider minor accidents as a normal part of my daily work, iii) health and safety laws are biased against the small -scale miners, iv) it is difficult to follow health and safety procedures, v) workers react strongly against other workers who break health and safety rules, I feel safe in my work environment? vi) mine dust is the cause of diseases such as pneumoconiosis, silicosis, lung cancer and mesothelioma. vii) high of dust exposure levels in mines could cause occupational lung diseases amongst mineworkers. and viii) do you think some ex-mineworkers got ill or died due to exposure to crystalline silica or mine dust?

3.5.2 Outcome variables

The outcome variable for the study was the practice score, which was calculated by allocating 1 for a correct answer (yes), while the "no" was an incorrect answer and allocated a score of 0. We then added the correct answer to get an individual score (with a possible score ranging from 0-14). The questions on practice are presented in ***Table 2***.

Table 2: Questions on the practices related to respirable crystalline silica dust.

1. There is evidence of health and safety implementation strategy in my company
2. Do you hold health and safety meetings regularly
3. Does your employer conduct dust and noise surveys at regular intervals?
4. The employer conducts individual risk assessments before commencing your duties as an employee
5. There is a health and safety representative in my work area.
6. Taking air measurements for dust at the mine is good practice for controlling dust exposures?
7. Spraying water/chemical agents on travel/haul roads is an effective way to reduce dust levels.
8. Keeping the dump truck's cabin door closed is a good practice to keep dust levels low inside.
9. Wearing a dust/paper mask is important when working in dusty areas.
10. Wearing a dust/paper mask is important when working with chemicals, gases or vapours.
11. I can protect my hands from workplace hazards/risks by wearing good protective gloves.
12. Following approved re-entry times after blasting will limit your exposure to dust and blasting fumes/gases.
13. Wearing hearing protection (earplugs/earmuffs) at work will protect you from going deaf.
14. I have received health and safety awareness training within the last 12-24 months.

3.5. Data Processing and Management

The Secondary data from the questionnaire was extracted from the main study, which holds records of data from different selected mines in Lesotho. The data was encrypted with a password known only to the principal investigator. The data from the questionnaire was captured on an Excel spreadsheet, cleaned for errors and any possible outliers; and thereafter, a code sheet was developed. Research Identifiers were removed. Descriptive statistics, including percentages and mean values such as age, education, job title, experience, knowledge of exposure to silica dust, knowledge on the control of risk factors associated with exposure to silica dust, knowledge on exposure health effects, knowledge on health and safety policies and laws, knowledge on health and safety procedures, training and information; were performed to examine the central tendency and variability of the data obtained using the questionnaire. Frequencies and percentages were used to present categorical variables.

3.6 Data Analysis

The data collected in the main study during the SATBHSS project, using a questionnaire was entered, cleaned and coded in MS Excel. It was then exported and analyzed using STATA software, version 17. The descriptive data was presented in frequencies and percentages using tables and figures for categorical variables. The continuous variables were presented in mean (with standard deviation), median and range. For inferential analysis to determine the factors influencing practice among the study participants, regression analysis was used. A linear regression model was used to determine the factors influencing practice scores. Firstly, a bivariate analysis was conducted to determine an association between the dependent variable (practice score) and with independent variables (socio-demographics, knowledge and attitude variables). Those independent variables that had a significant association with practice scores were included in the final multivariate analysis. The variables that had a significant association in the final model were deemed to influence practices in the study population. The level of statistical significance was set at 0.05.

3.7 Reliability and Validity

Main Study

The primary data was collected using a questionnaire-based survey to collect data for the main study by SATBHSS. The questionnaire in the main study was designed using existing literature and expert advice. The questionnaire was made clear and easy for participants to understand. To ensure this, the questionnaire was translated by a professional transcriber into Sesotho, a local language, spoken by the majority of the participants and then translated back into English to ensure accuracy. The questionnaire was constructed using closed-ended questions. Furthermore, the study question's validity and reliability were checked by piloting prior to the actual study, and the results from the pilot study were not included in the analysis.

3.8 Ethics

Main Study:

The main study protocol was approved by the Lesotho Ethics Committee on the 19th of September 2018, reference number ID128-2018. Permission to do the study was also

approved by the Ministry of Mines and Mining Operations. Participants were informed about the research project ahead of time and provided consent before data collection commenced. Informed consents were obtained in writing for all participants who participated and permission to publish any pictures captured during the study was also obtained from the participants and mines. Participants were informed of their rights, freedom, privacy and anonymity, as well as the fact that their participation in the study was entirely voluntary, with an option to withdraw at any time during the interview without giving a reason.

Current Study:

The study was ethically cleared by the University of the Witwatersrand Human Research Ethics Committee (HREC): certificate number [M231180], appendix 5 and the Belmont report, which reported three key principles, namely, respect for people, beneficence, and justice (The Belmont report, 1978). Permission to use the research study results was granted by AUDA-NEPAD, see Appendix 3. For security reasons, the data obtained from the main study was protected and accessible only to the principal investigator to ensure confidentiality. The principal Investigator received the certificate of research ethics from Training and Resources in Research Ethics Evaluation (TRREE) that was completed and passed at a satisfactory level.

CHAPTER FOUR

This chapter presents the results found from the evaluation of knowledge, attitudes and practices of mine workers on factors that increase the risk of respirable crystalline silica dust exposure in selected mines in Lesotho. This chapter further presents results on the participants' demographic characteristics, knowledge of respiratory crystalline silica dust among mine workers, practises linked to prevention and protection against respirable crystalline silica dust as well as factors that influence the practice related to respirable silica dust prevention.

4. Results

4.1 Demographic characteristics

The demographic of participants is represented in ***Figure 4*** below. A total number of 385 participants aged between 21 and above 60 years of age from selected mines, participated in the study to have an insight into the mine worker's knowledge, attitudes and practices on factors influencing the risk of silica dust exposure in Lesotho. Out of the total participants who took part in the study, the majority were Basotho with 96 %, South Africans with 1% and others with 3%. The gender distribution for mine sites is also presented and there was a significant gender disparity with 35 (9%) females and 350 (91%) males. The majority of the study participants were predominantly male, potentially attributed to the demanding nature of labour in the mining sector, which traditionally relies on a predominantly male workforce. A total of 275 (71%) participants were single, while 105 (27%) participants were married, and 5 (2%) participants widowed.

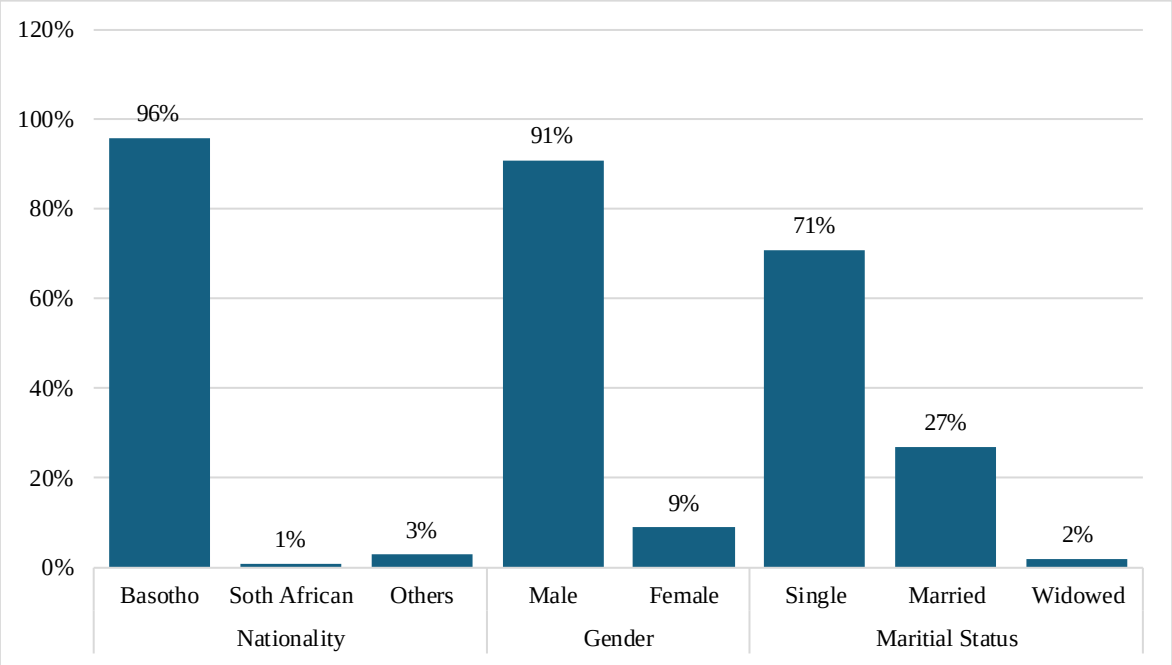

Figure 4**:** Demographic information of the participants.

The age analysis of the participants who took part in the study was as follows; 122 participants were between the ages of 21 to 30 years old, 167 were between the ages of 31 to 40 years, 57 were between 41 to 50 years, 34 were between 51 and 60 years old and 5 were 61 years and above. Most of the participants were between the age of 31 to 40 years of age with 21 years being the minimum age, while 61 and above is the maximum age of the participants. Age was a crucial aspect to take into account when evaluating the risk associated with silica dust exposure among mine workers, given the well-established fact that there exists an evident difference in the level of knowledge between younger and older employees. According to existing literature, it has been extensively noted that younger workers exhibit a lesser degree of understanding regarding matters concerning their health and safety compared to their older counterparts (Rohlman *et al.*, 2013; Dragano *et al.*, 2018). The diminished knowledge of occupational risks such as respirable crystalline silica dust exposure among younger workers may be attributed to limited knowledge and work experience (Rohlman *et al.*, 2013). Figure *5* represents the age of the participants who took part in the study.

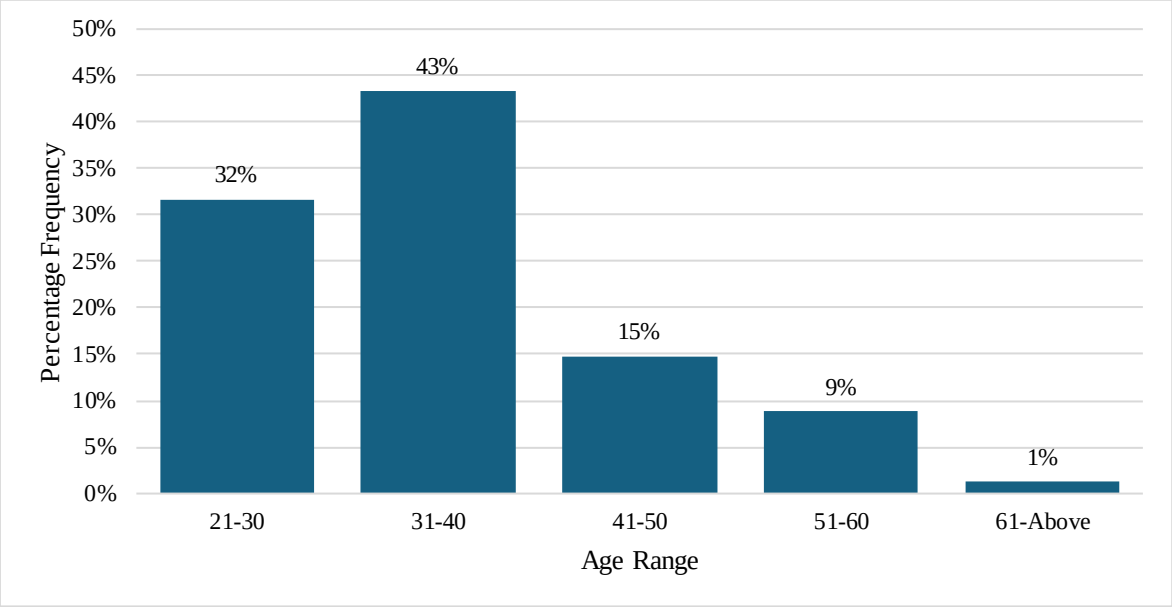

Figure 5: Age of Participants

Results presented in ***Figure 6*** illustrate the level of education achieved by the participants. Among the study participants, a notable diversity in educational attainment is observed. While a minority of Individuals with a postgraduate degree accounted for 10 (3%) of the total participants, compared to 25 (6%) of those with a degree as their highest level of education. Those who had a diploma as their highest level of education were 45 (12%), and the rest of the participants had a high school level of education which was 305 (79%). These results reveal an intriguing distribution, indicating a potential knowledge gap and varied impact of silica dust exposure on participants across the observed different educational backgrounds. According to the existing literature, workers with higher levels of education demonstrate a deeper understanding of health risks associated with silica dust exposure and are more proactive in adopting preventative measures. Conversely, workers with only a high school level of education demonstrate limited knowledge regarding the factors that influence the risk of silica dust exposure (Aluko *et al.*, 2016; Thuhuyen *et al.*, 2023) . A study conducted by Aluko *et al*., (2016) indicated a correlation between occupational hazard knowledge and level of education. Additionally, a study conducted by Sifanu *et al*., (2023) established a positive relationship between educational attainment and workers' awareness of the adverse health effects of silica dust exposure. Furthermore, findings from the existing research studies suggest that mine workers with higher educational levels possess a more comprehensive understanding and knowledge of the health risks associated with silica dust

exposure compared to their counterparts with lower levels of education (Francis *et al*., 2021; Tadesse *et al*., 2016) .

This disparity in the level of education could reflect different roles and responsibilities within the mining industry, with workers who possess higher education being in managerial positions or technical positions with potentially lower exposure to silica dust, whereas those with only high school level are more likely to engage in tasks with direct exposure to respirable crystalline silica dust (Fluck *et al*., 2021).

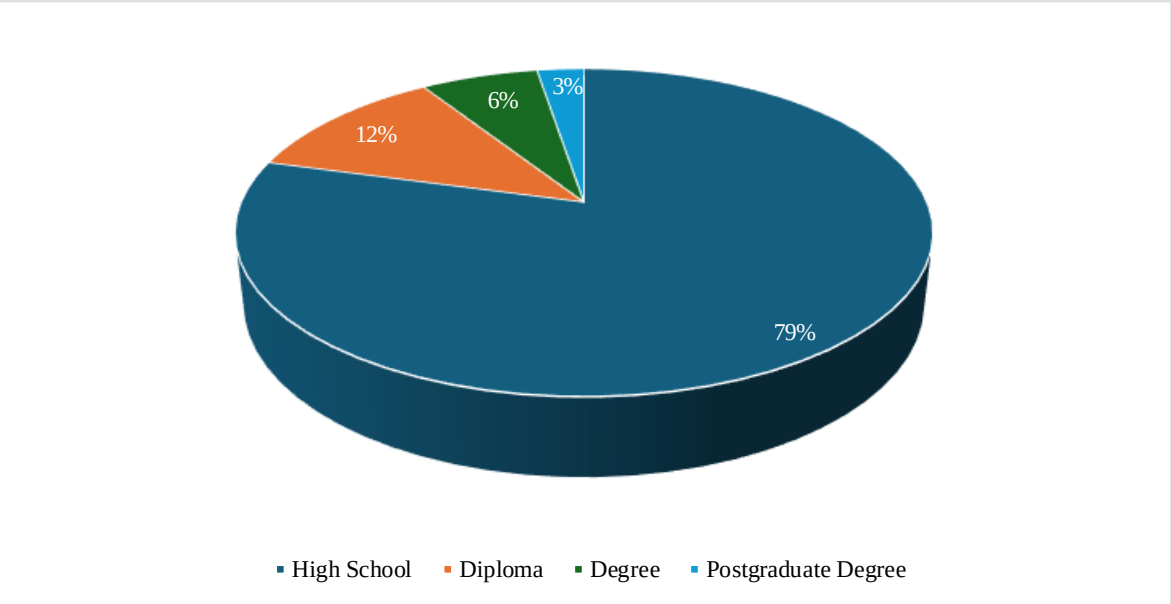

Figure 6: Level of education of the study participants.

The results depicted *in* ***Figure 7*** below, show that, out of 385 participants, a total of 185 (48%) participants reported to be working as general workers, 155 (40%) working as plant operators, 30 (8%) working as supervisors and 15 (4%) working as drivers. Understanding job titles is essential for addressing silica dust knowledge, attitudes and practices in mining settings. Traditionally, it is suggested that there is a disparity in the risk of exposure to respirable silica dust among manual workers such as general workers, plant operators and non-manual workers such as supervisors and drivers. It is commonly assumed that manual workers face a higher risk of respirable dust exposure than their non-manual counterparts (Fluck *et al*., 2021). This disparity in exposure levels arises from a multitude of factors, including the nature of work, the duration of exposure, and the level of education, which plays a critical role in enhancing knowledge and improving work practices related to silica

dust exposure, aiding in the mitigation of silicosis development (Thuhuyen *et al.*, 2023). Addressing this disparity requires a comprehensive approach, including educational programs to assist workers in changing their attitudes and work practices.

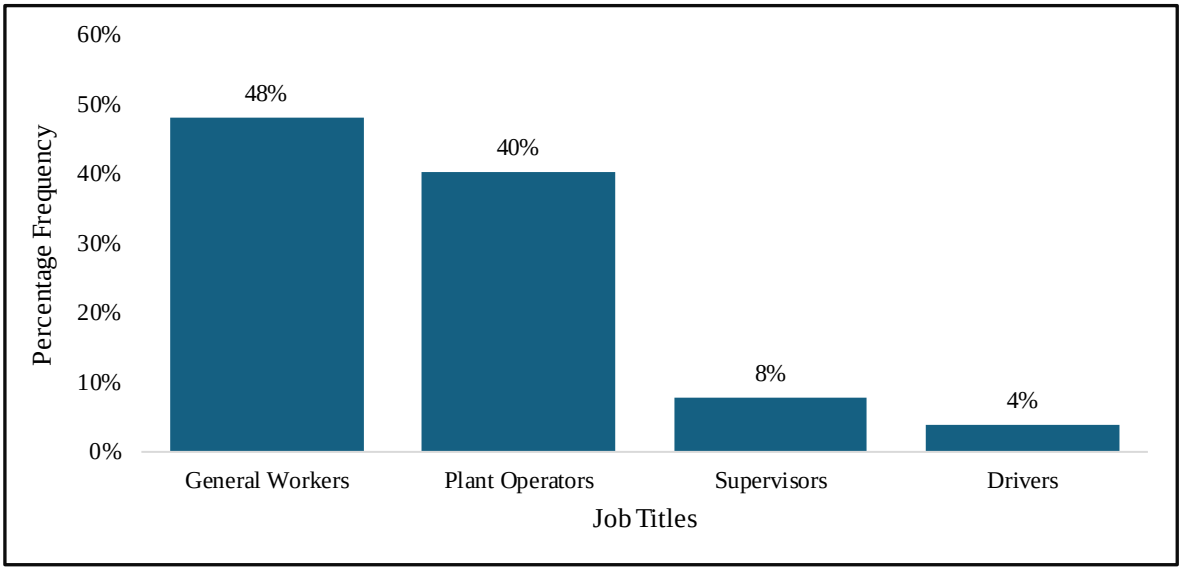

Figure 7: Miner's Job titles.

Figure 8 below illustrates the miner's work experience in the mining industry. Workers with 1- 10 years' work experience accounted for 285 (74%) of the total, compared to 90 (23%) of those with 11- 20 years of experience as well as those with 21 years and above of experience who accounted for 10 (3%). According to the available research studies, fieldwork experience, interest in occupational health and safety, and webinar attendance have been identified to enhance knowledge, attitudes and practices related to occupational health and safety within the mining industry (Sunandar and Yodang, 2021). Work experience is a key factor that influences safety awareness among workers. A research study conducted by Francis *et al*., (2021), revealed that workers who had 6 to 10 years and more years of work experience demonstrated a higher level of knowledge regarding the adverse health impacts of silica dust exposure in comparison to their counterparts who had 1 to 5 years work experience. The existing research studies have established a positive correlation between work experience, level of education, and awareness among workers concerning the detrimental health effects of exposure to silica dust (Francis *et al*., 2021; Tadesse *et al*., 2016)

According to Hasanzadeh et al., (2017), health and safety knowledge attained through work experience can improve workers attitudes and work practices.

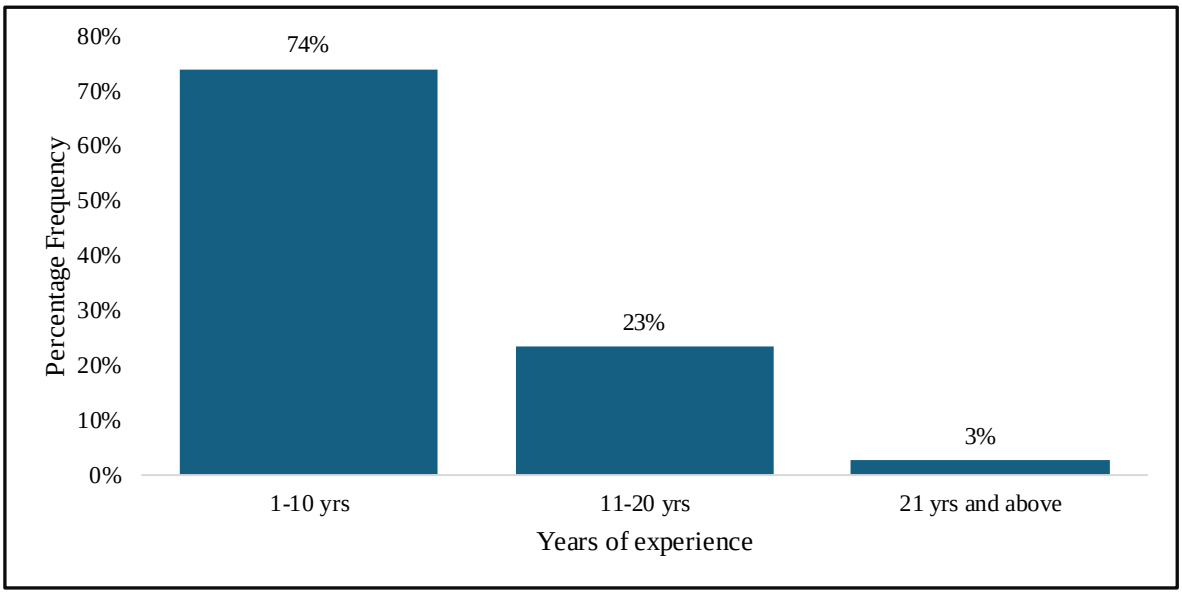

Figure 8: Mine worker's experience.

The primary commodities mined in Lesotho are depicted in ***Figure 9*** Below are mainly diamond, sandstone, and dolerite, with 185 (48%), 120 (31%), and 80 (21%) respectively, with Diamond being the primary commodity with the highest number of workers in the selected mines in Lesotho.

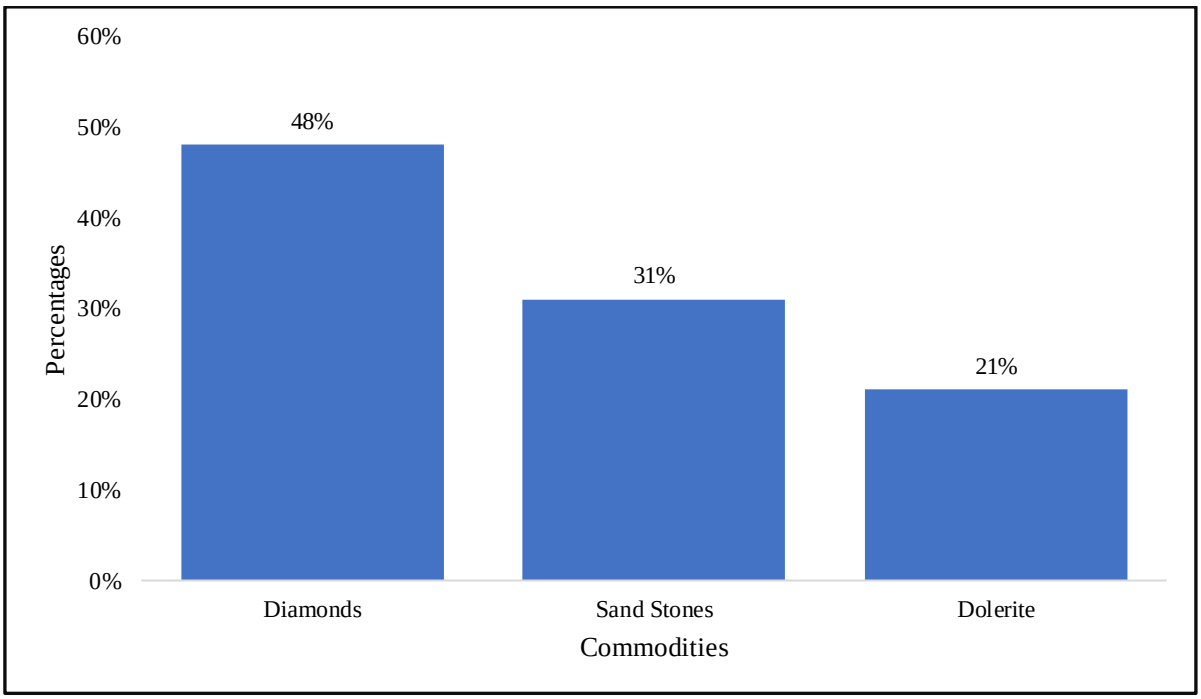

Figure 9: Primary commodities.

4.1.1 Knowledge of respirable crystalline silica dust among mine workers

Figure *10* shows participants' knowledge response regarding respiratory crystalline silica dust exposure. This study indicated high awareness of lung cancer, level of noise and safety stressors with 91%, 99% and 96%, respectively. At the same time, there is a significant difference in the knowledge of physical stressors. The study showed that 90% of the participants did not know about workplace physical stressors. Furthermore, the average knowledge was 13.43 with a standard deviation of 2.99. While the knowledge score ranged from 6 to 19 and the median was 14.00.[1]

[1] H&S stands for Health and Safety

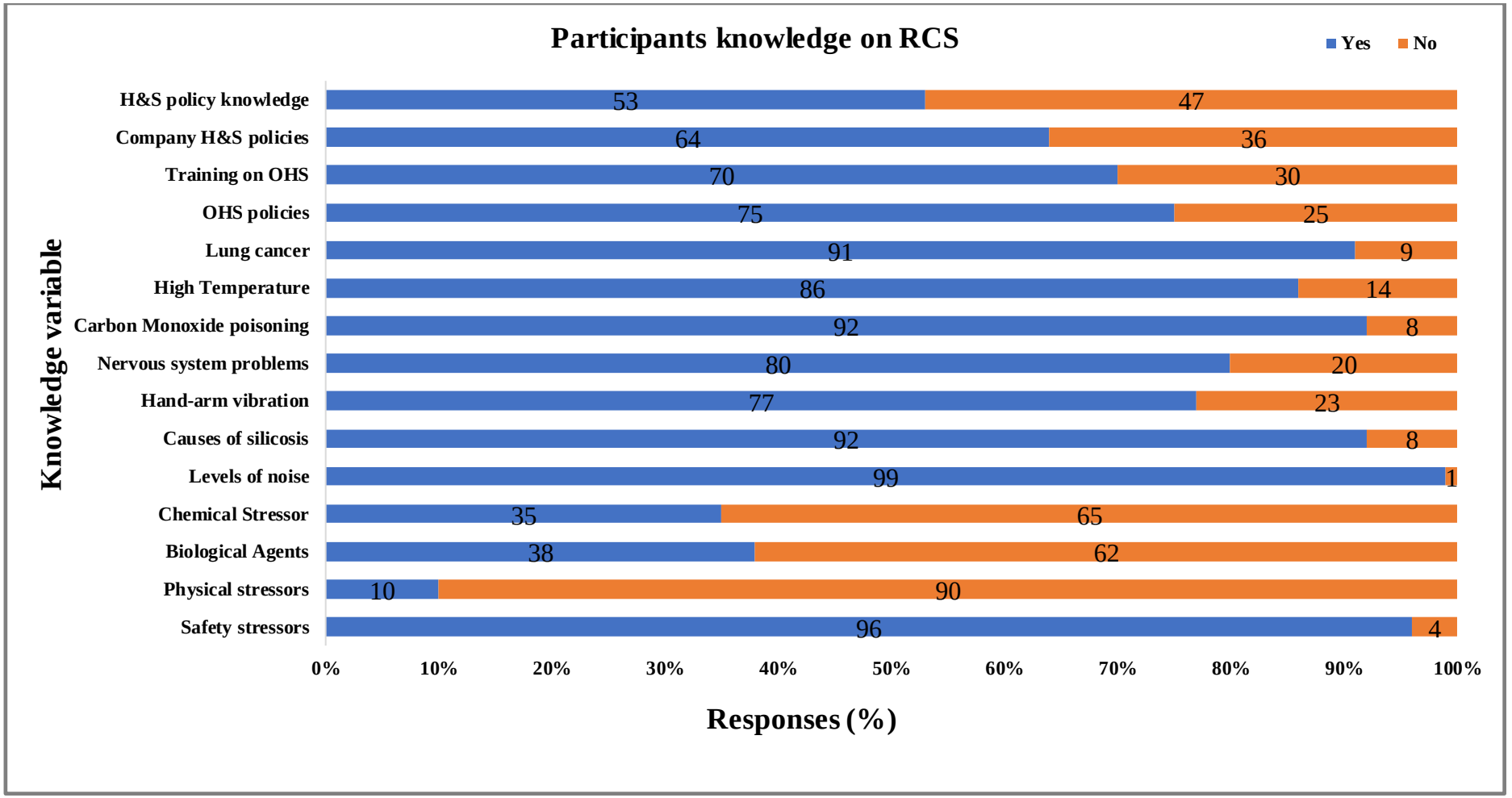

Figure 10: Participants knowledge response on respirable crystalline silica dust.

4.1.2 **Study participants' attitude**

One hundred percent of the respondents thought that high dust exposure in mining operations could be the reason mine workers develop occupational lung diseases (**Figure 11**). Moreover, 92% of the respondents thought that mine dust was the primary cause of diseases such as mesothelioma, pneumoconiosis, and lung cancer. About 86% of the respondents believed that exposure to crystalline silica dust had a great contribution to the illnesses and deaths of some of the former miners. Slightly more than half of the respondents, 58%, agreed to take harsh action against workers who violate the health and safety rules set in place to protect the safety of their coworkers. The majority of respondents (82%) disagreed that health and safety laws are biased against small-scale miners. More than half of the respondents—75% disagreed with the notion that their workplace is meant for the brave and not for the people who are concerned about their health and safety, while 65% believed that minor accidents are normal parts of the work daily activities.[2]

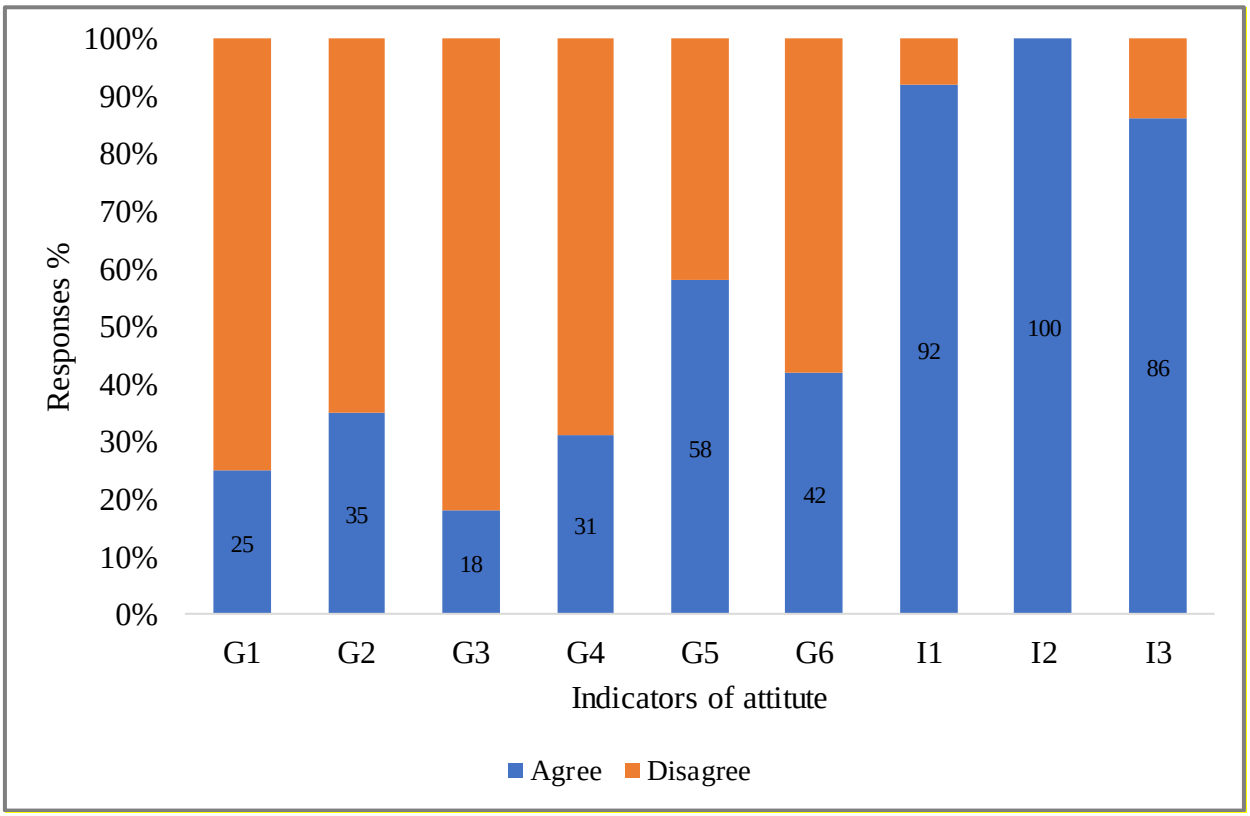

Figure 11: Workers' attitude response on factors or conditions leading to dust exposure.

[2] G = Questions on workers' attitude regarding health and safety policies (Appendix 6)

4.1.3 Practices linked to prevention and protection against respiratory crystalline silica dust

According to ***Table 3,*** 210 (55%) of participants who work in Lesotho mines reported having evidence of health and safety implementation strategy in their workplace. Two- hundred and thirty (60%) reported that they hold health and safety meetings regularly, and 155 (40%) mine workers reported that their employer conducts dust and noise surveys at regular intervals, while 250 (65%) participants reported that the employer conducts individual risk assessment prior commencing with their duties.

A total of 215(56%) revealed that health and safety representatives are available in the working area. One- hundred and seventy-five participants (46%) reported that taking air measurements for dust at the mine is good practice for controlling dust exposures. Another 375 (97%) reported that spraying water/chemical agents on travel/haul roads effectively reduces dust levels, whereas 340 (88%) indicated that keeping the dump truck cabin door closed is a good practice to keep dust levels low inside. Wearing a dust/paper mask was important to 365 (95%) participants when working in dusty areas, while wearing a dust/paper mask was reported as important when working with chemicals, gases or vapours to 345 (90%) participants.

Three hundred fifty could protect hands from workplace hazards/risks by wearing good protective gloves. Two hundred sixty (69%) reported that the following approved re-entry times after blasting limit exposure to dust and blasting fumes/gases. Three hundred (78%) wear hearing protection (earplugs/earmuffs) at work to prevent becoming deaf. The study revealed that a low percent of 180 (47%) received health and safety awareness training within the last 12-24 months.

Table 3 : Participants responses on the practices related to respirable crystalline silica dust exposure.

Question	**n (%)**
1. There is evidence of health and safety implementation strategy in my company	210 (55%)

2. Do you hold health and safety meetings on a regular basis	230 (60%)
3. Does your employer conduct dust and noise surveys on regular intervals?	155 (40%)
4. The employer conducts individual risk assessments prior commencing your duties as an employee	250 (65%)
5. There is a health and safety representative in my work area.	215 (56%)
6. Taking air measurements for dust at the mine is good practice for controlling dust exposures?	175 (46%)
7. Spraying water/chemical agents on travel/haul roads is an effective way to reduce dust levels?	375 (97%)
8. Keeping the dump trucks cabin door closed is a good practice to keep dust levels low inside?	340 (88%)
9. Wearing a dust/paper mask is important when working in dusty areas?	365 (95%)
10. Wearing a dust/paper mask is important when working with chemicals, gases or vapors?	345 (90%)
11. I can protect my hands from workplace hazards/risks by wearing good protective gloves?	350 (91%)
12. Following approved re-entry times after blasting will limit your exposure to dust and blasting fumes/gases?	265 (69%)
13. Wearing hearing protection (earplugs/earmuffs) at work will protect you from going deaf?	300 (78%)
14. I have received health and safety awareness training within the last 12-24 months.	180 (47%)

In terms of practices related and unrelated to the risk of silica dust exposure, the participants correctly identified an average of 265 (69%) related practices and an average of 300 (78%)

practices not related to the exposure of silica dust was identified as such. Approximately, 340 (88%) participants correctly identified the activities related to silica dust exposure. According to 375 (97%) of mine workers, the spraying of water/chemical agents on travel/haul roads was an effective way to reduce dust levels.

4.1.4 Factors that influence the practice related to respiratory silica dust prevention in the study

The bivariate analysis between practice score and socio-demographic variables is presented in ***Table 4***. The analysis showed that there was an association between practice scores with age (p≤0.001), education (p≤0.001), job title (p≤0.001), gender (p=0.005), occupation (p≤0.001) and commodity mined (p≤0.001).

Table 4: Bivariate regression analysis of socio-demographics influencing the practice score.

VARIABLE	COEFFICIENT [95%CI]	P-VALUE
Socio-demographics		
Age	0.91 (0.61 to 1.22)	≤0.001*
Education	0.75 (0.32 to 1.18)	≤0.001*
Gender	1.53 (0.46 to 2.59)	0.005*
Marital Status	- 0.07 (-0.71 to 0.56)	0.822
Job Title	0.59 (0.27 to 0.91)	≤0.001*
Years working in the mine	0.50 (-0.14 to 1.13)	0.123
Primary Commodity	-2.33 (-2.65 to -2.01)	≤0.001*

* p-value for statistically significant was set at 0.05 or less

Results presented in ***Table 5***, demonstrates a significant contribution of the influence of knowledge and attitude on practice. This finding implies that with improved knowledge and a positive attitude, practice can be achieved. This further suggests a correlation between enhanced knowledge and a positive attitude towards the factors affecting the risk of silica dust exposure, consequently, promotes a shift in behaviour, culminating in the adoption of best practices. The variables in this table , D,G, and I respectively, are presented in appendix 6.

Table 5: Bivariate regression analysis of knowledge and attitude influencing the practice score.

VARIABLE	COEFFICIENT [95%CI]	P-VALUE
Knowledge		
Safety stressors	-2.34 (-2.91 to -0.75)	0.004*
Physical stressors	_1.68 (-2.67 to -0.68)	0.001*
Biological stressors	0.89 (0.26 to 1.52)	0.006*
Chemical stressors	-0.08 (-0.72 to 0.57)	0.817
D1	-4.30 (-7.00 to -1.60)	0.002*
D2	0.81 (-0.33 to 1.97)	0.164
D3	0.62 (-0.11 to 1.34)	0.095
D4	1.68 (0.91 to 2.44)	≤0.001*
D5	2.62 (1.50 to 3.74)	≤0.001*
D6	0.34 (-0.53 to 1.23)	0.439
D7	0.35 (-0.72 to 1.43)	0.514
E1	3.17 (2.52 to 3.81)	≤0.001*
E2	3.18 (2.58 to 3.78)	≤0.001*
E3	4.16 (3.66 to 4.65)	≤0.001*
E4	4.91 (4.53 to 5.29)	≤0.001*
Knowledge score	0.76 (0.68 to 0.82)	≤0.001*
Attitude/ perception		
G1	1.45 (0.74 to 2.16)	≤0.001*
G2	-1.16 (-1.80 to-0.52)	≤0.001*
G3	-0.48(-1.284862 to 0.32)	0.235
G4	-0.85(-1.51 to- 0.19)	0.012*
G5	3.21 (2.67 to 3.75)	≤0.001*
G6	3.58 (3.06 to 4.09)	≤0.001*
I1	3.71 (2.62 to 4.8)	≤0.001*
I2	0 (omitted)	-
I3	2.05 (1.19 to 2.91	≤0.001*

* The p-value for statistical significance was set at 0.05

The final multivariate linear regression showing factors influencing the practice in the study, is presented in ***Table 6*** .The following factors influence practices related to respiratory silica dust prevention in the study; being at the age of 31 to 40 years old (p <0.001; 95% CI:0.35 to 1.03), being a male mine worker (p=0.002; 95% CI:0.35 to 1.03), working in a dolerite mine (p=0.003; 95% CI:0.35 to 1.66), knowledge score (p<0.001; 95% CI: 0.37 to 0.59), having positive (agree) attitude towards minor accidents at the mine (p=0.007; 95% CI:-1.05 to -0.16) and having positive (agree) attitude about health & safety rules at the mine (p<0.001; 95% CI:0.92 to 0.79).

Table 6: multivariate linear regression shows factors influencing the practice in the study.

Factor	**COEFFICIENT (std. error)**	**P-VALUE**	**Confidence Interval [95%CI]**
Age			
21 to 30 years old	ref		
31 to 40 years old	0.68 (0.17)	<0.001*	0.35 to 1.03
41 to 50 years old	-0.54 (0.23)	0.020*	-0.99 to -0.08
51 to 60 years"	-0.91 (0.31)	0.003*	-1.52 to -0.30
61 years old & above	-1.65 (0.60)	0.007*	-2.83 to -0.46
Gender			
Female	ref		
Male	0.91 (0.29)	0.002*	0.34 to 1.47
Primary commodities			
Diamonds	ref		
Sandstone	-0.31 (0.26)	0.241	-0.83 to 0.20
Dolerite	1.01 (0.33)	0.003*	0.35 to 1.66
Knowledge Score			
Score	0.48 (0.06)	<0.001*	0.37 to 0.59
Attitude towards minor accidents at the mine			
Disagree	ref		
Agree	-0.61 (0.23)	0.007*	-1.05 to -0.16
Attitude about health & safety rules at the mine			
Disagree	ref		
Agree	1.36 (0.22)	<0.001*	0.92 to 1.79

* The p-value for statistical significance was set at 0.05

CHAPTER FIVE

5. Discussion: Introduction

This chapter discusses key findings as presented according to the study's objectives. Furthermore, the strengths and limitations of the study design, methodology, and results are thoroughly discussed and compared with others from published studies. Additionally, practical recommendations are provided for the integrated management of crystalline silica dust exposure among mine workers in Lesotho.

5.1 Demographics of Participants

The demographic of participants is represented in the results section above. In this study, a total number of 385 participants aged 21 to 60 years and above participated in this cross-sectional study designed to gain insight into knowledge. Attitudes and practices of mine workers on factors that increase the risk of silica dust exposure in selected mines in Lesotho. The results of this study demonstrated that most of the participants were in the age of 31 to 40 years of age and there was a significant difference in gender distribution with 35 females (9%) and 350 males (91%). The majority of the participants had a high school level of education which was 305 (79%), compared to those with a diploma as their highest level of education which were 45 (12%) and to 25 (6%) of those with a degree as their highest level of education, while a minority of Individuals with a postgraduate degree accounted for 10 (3%) of the total participants. Of the participants, 275 (71%) were single, while 105 (27%) were married and 5 (2%) were widowed. A total of 185 (48%) participants reported working as general workers, 155 (40%) working as plant operators, 30 (8%) working as supervisors and 15 (4%) working as drivers. The primary commodities mined in Lesotho are mainly Diamond, sandstone and dolerite with 185 (48%), 120 (31%) and 80 (21%), respectively.

5.2 Knowledge on silica dust exposure risk factors

In this regard, the study determined participants' correct and incorrect knowledge responses regarding respiratory crystalline silica dust exposure. The findings of this study revealed good knowledge of lung cancer, level of noise and safety stressors with 91 %, 99% and 96 % respectively. In addition, most of the workers (75%) knew about the preventative safety precautions through OHS policies. However, this study further revealed a significant

difference in knowledge of occupational hazards such as physical, chemical, and biological stressors. The findings indicated that 90% of the mine workers were unaware of the physical stressors present in their work environments, with 65% and 62% lacking knowledge of chemical and biological hazards, respectively. A previous study highlighted that chemical, physical, ergonomic, biological, and psychosocial stressors in workplaces interact to create a comprehensive system that imposes a collective stress burden on mine workers, ultimately resulting in work-related diseases. Nevertheless, traditional occupational health risk assessment fails to fully account for the intricate nature of the mining work environment (Zhang *et al*., 2024). Hence, understanding the occupational risks associated with exposure to silica dust is crucial as a sufficient level of knowledge could result in behavioural change, including adherence to established protocols aimed at reducing exposure. This research study's findings further demonstrated an average knowledge level of 13.43 with a standard deviation of 2.99, while the knowledge score ranged from 6 to 19, and the median was 14. Therefore, the findings of this study imply that there was a decline in knowledge of risk factors influencing workers' exposure to silica dust.

The findings of this study concurs well with a study conducted by Ge *et al*., (2020) , which reported that little is known about the risk factors that influence workers' exposure to silica dust in mining industries. Another study by Sifanu *et al*., (2023), also supports the findings of these two studies that, there is still a lack of knowledge regarding silica dust exposure, particularly in the SADC region. However, contrary findings were reported in a study conducted by Maboso *et al*., (2023) , which found that miners' knowledge of silicosis has increased since the early twentieth century. Therefore, to understand the problem at hand, further evaluation of mine workers' knowledge of factors that increase the risk of silica dust exposure in selected mines in Lesotho is needed.

5.3 Attitudes on silica dust exposure risk factors

In terms of attitudes on silica dust exposure risk factors among mine workers in Lesotho. This study revealed that most respondents had a positive attitude toward safety practices and the prevention of occupational hazards. This was shown by 100% of the respondents who believed that high dust exposure in mining operations could be the reason mine workers develop occupational lung diseases. Additionally, the study found that 92% of the respondents thought that mine dust was the primary cause of diseases like mesothelioma,

pneumoconiosis, and lung cancer. Moreover, about 86% of the respondents believed that exposure to crystalline silica dust had a great contribution to the illnesses and deaths of some of the former miners. Slightly more than half of the respondents, 58%, reported that they take harsh action against workers who violate the health and safety rules set in place to protect the safety of their coworkers. The positive attitude observed among mine workers in Lesotho mines may stem from the extensive knowledge demonstrated by the respondents regarding safety stressors. This could also be attributed to the fear of occupational illnesses that have the potential to be both terminal and life-threatening in some instances. The findings of this research align with those of a previous study carried out by Khuthalo, (2018) in a coal mine, where workers exhibited a strong appreciation of attitudes towards occupational exposure.

The majority of respondents, 75% disagreed with the notion that their workplace is meant for the brave and not for the people concerned about their health and safety. Additionally, about 70% of the respondents reported attending training on occupational health and safety precautions. However, more than half, 65% of the respondents, believed that minor accidents are normal parts of the world of daily work activities. The findings of this study imply that a comprehensive understanding and knowledge of the factors influencing the risk of silica dust exposure is crucial for cultivating positive attitudes in mining operations. Whereas a lack of knowledge regarding these factors contributes to negative attitudes among mine workers. This finding is in tandem with the findings of a study conducted by Sifanu *et al*., (2023) , which underscored the significance of knowledge in fostering positive attitudes that can promote proper workplace practices to minimize respirable dust exposure.

5.4 Practices of mine workers on silica dust exposure prevention measures and controls

Understanding and implementing effective practices for the prevention and protection against respirable crystalline silica is paramount in mining operations. ***Table 3*** present summaries of mine workers' responses to questions related to practices linked to prevention and protection against silica dust. The findings indicated that the majority (95%) of the participants reported that wearing a dust/paper mask was important when working in dusty areas. Notably, 91% of participants reported that they protect their hands from workplace

hazards/risks by wearing good protective gloves. The analysis further shows that 78% of the participants wear hearing protection devices (earplugs/earmuffs) at work to protect themselves from becoming deaf. However, predominantly depending on hearing protection devices is not considered a sound practice (Naicker, 2024). A previous study by Kerr *et al*., (2017) reported that attitudes and practices are significantly influenced by the education workers receive on Noise Induced Hearing Loss (NIHL) and the industry's existing occupational health and safety culture.

This study demonstrated that most (60%) of the mine workers reported regularly holding health and safety meetings. Additionally, this study revealed that nearly all the participants (97%), reported that spraying water/chemical agents on travel/haul roads is an effective way to reduce dust levels, whereas 88% of the participants indicated that keeping the dump truck cabin door closed is a good practice to keep dust levels low inside. The study further showed that the overall practices of the majority of the mine workers were reasonably good. This is corroborated by the findings of a study conducted by Haas *et al*., (2016), where it was observed that mine workers exhibited a profound understanding and knowledge of health-protective practices in relation to respirable silica dust exposure to the point that they demonstrated a commitment to wearing respiratory protective equipment, even in locations where its usage was not required. Furthermore, the study conducted by You *et al*., (2019) reported that knowledge of safety played a role as a mediator in the unsafe behaviour propagation of mine workers. However, there was a significant difference relating to mine worker's practices. This study demonstrated critical findings. It was observed that a low percentage, 40% of the study population, reported that their employer conducts dust and noise surveys at regular intervals. Additionally, the study revealed that only 46% of the participants reported taking air measurements for dust at the mine as a good practice for controlling dust exposures. Furthermore, it was found that, 53% of the participants indicated that they never received health and safety awareness training within the last 12- 24 months. The study findings indicates that it is imperative for the management of the mining sites to implement education programs aimed to improve knowledge and understanding of the risks associated with exposure to respirable silica dust. This will enable mine workers to incorporate this knowledge into positive attitudes and practices. Therefore, this study highlighted a need to integrate administrative controls such as knowledge and behavioural

components into the established controls, to further reduce the excessive exposure of mine workers to respirable crystalline silica dust.

5.5 Factors that influence practices relating to silica dust exposure in the study

The bivariate regression analysis of knowledge and attitude influence on the practice score is presented in **Table 5**. The current study demonstrated a notable impact of knowledge and attitude on practices regarding risk factors that influence exposure to silica. This finding implies that enhanced knowledge and a positive attitude can lead to improved practices.

5.5.1 Age

The final multivariate linear regression, showing factors influencing the practice in the study, is presented in **Table 6**. The relationship between mine workers' age and the level of understanding of respirable silica dust exposure revealed some intriguing results. It is generally expected that elderly workers demonstrate a better and greater understanding of occupational health and safety issues. Surprisingly, this study's results showed a different picture. The results of this study indicated a significant correlation between middle-aged, 31 to 40 years old ($p < 0.001$; 95% CI: 0.35 to 1.03) mine workers and the level of knowledge of the factors contributing to the risk of silica dust exposure, whereas older workers, 61 years old & above were more likely to be ignorant of those factors. This finding contradicts the findings of Siziya *et al*., (2013), who found that older employees were more aware of workplace health hazards than their younger counterparts. Another study conducted by Dragano *et al*., (2018) also yielded contradictory findings. The results of this study do not agree with the body of existing literature in this regard, and this could potentially be attributed to the demographic makeup of the current study participants, who predominantly consisted of middle-aged mine workers. This composition may have inadvertently introduced a response bias, which indicates that the relationship between age and knowledge is intricate or complex and requires further research to fully comprehend complexities.

5.5.2 Work Experience

The number of years worked in mining operations was determined in the study. The findings demonstrated a significant correlation between work experience and worker's level of knowledge of the factors contributing to the risk of silica dust exposure. The results

highlighted that mine workers who spent more years working in mine industries demonstrated a superior understanding and knowledge of the factors contributing to the risk of silica dust exposure than those who have been in the industry for fewer years. The findings of this study imply that as work experience increases, understanding of the contributing factors to the risk of silica dust exposure increases. This finding concurs with what Francis *et al*., (2021) found in their study that the more experience of years worked in mining operations, the more the knowledge of the adverse health effects of silica dust exposures. A study by Tadesse *et al*., (2016) also discovered a positive correlation between increased work experience and workers' awareness of occupational health hazards, which coincides with this study's findings.

5.5.3 Education level

The study demonstrated that education positively correlated with knowledge of the factors influencing the risk of silica dust exposure, with mine workers having a higher level of education being more aware of the health risks associated with silica dust exposure than those with only a primary or no education. The findings of this study suggest that a worker's understanding of the implications of silica dust exposure improves with education. This finding is unsurprising, as individuals with higher levels of education typically possess a greater and deeper understanding of issues related to occupational health risks Şenkal *et al*., 2021, in their study on knowledge, attitudes, and perceptions of occupational hazards and safety practices among healthcare professionals identified a positive associated between educational attainment and knowledge of occupational health. In addition to this, a study by Siziya *et al*., (2013) revealed that highly educated people are more likely to understand hazardous exposures and take precautions to prevent them. Based on these findings, it can be concluded that higher educated mine workers comprehend the health risks associated with exposure to silica dust better than those with lower or no educational background. It has been established that higher educational attainment is significantly associated with worker's health hazard awareness (Tadesse *et al*., 2016).

Therefore, there is still an urgent need to efficiently manage silica exposure by using knowledge to change workers' perceptions and promote good practices that support all

workplace exposure controls. This study's findings provide crucial information for policymakers to devise measures to minimize silicosis's prevalence in Lesotho mines.

5.6 Limitations of the study

This study employed a retrospective cross-sectional design, using a structured questionnaire to capture participants' responses, and might have invited the response bias. Participants from other mining sites provided limited data on the knowledge of health and safety procedures, limiting the generalisation of the findings on this parameter to the rest of the African continent with similar mine setups.

5.7 Strengths of the study

This is relatively the first study to fill the research gap on worker exposure to crystalline silica among mine workers in Lesotho. The study also assessed how knowledge could influence the attitude and worker practices towards exposure to crystalline silica, and this contributes significantly to informed decision-making on exposure control. This study will add value to the body of knowledge as there are limited research studies on crystalline silica dust exposure among mine workers, and no current published research studies were found in the context of Lesotho mines. The findings of this study may serve as the basis for national policy adoption, implementation, and contribution to the effectiveness of exposure control against exposure to crystalline silica dust in the Lesotho mines. Additionally, the findings of this study offer insights that may guide the development and implementation of educational interventions aimed at improving the attitudes and practices of mine workers regarding factors that increase the risk of silica dust exposure.

5.8 Recommendations

The following recommendations are made to assist the management of mines in Lesotho in controlling mine workers' exposure to silica dust:

- Ensure accurate data on employees exposure to respirable silica is gathered to identify and prioritize problem areas and resources to assist mines in reducing employee exposure. To gather accurate data, one or both of the following options need to be implemented:

- Occupational Hygiene monitoring of respirable silica has to be made mandatory for all mines operating within the Kingdom of Lesotho.
- Establish a mandatory code of practice (COP) geared towards the elimination of exposures to hazardous agents deemed to pose the most significant exposure risks within the mining sector.

- Ensure employers' compliance with legislated requirements regarding health and safety as per the local legislations and international best practices.
- Develop and disseminate risk awareness material, risk evaluation material, risk reduction, and risk management material to employees, employers, and state departments.
- Employers should be required to introduce policies and/or codes of conduct promoting effective control measures and providing for a safe work environment.
- Awareness of silicosis is markedly deficient among all demographic groups examined, indicating a necessity for heightened awareness levels and improved knowledge and understanding of preventative methods.
- The employer should prioritize the identification of dust sources and develop and implement, where reasonably practicable, measures aimed at controlling the dust at the source and, when not possible, providing employees with suitable Respiratory Protective Equipment to provide sufficient protection against airborne dust levels.
- The employer must ensure that mine workers are prevented from performing work in a manner that exposes them to unnecessary risk of exposure to health hazards.
- Conduct risk assessment and ensure that any occupational health and safety programme is a risk-based intervention.
- Provide technical guidance, training, coaching, and mentorship to train and upskill mine workers to identify substandard conditions and provide guidance on implementing controls to reduce mine worker's exposure to airborne dust.

- Provide technical guidance to ensure that best practice principles with regard to dust control are identified, considered in country-specific legislation.
- Support research on silicosis, focusing on KAP studies for mine workers.

CHAPTER SIX

This chapter provides a summary of the significant findings of the current study. This chapter synthesises insights reflecting on the risk of exposure to RCS dust and highlights the contribution of the current study towards the effectiveness of exposure control against exposure to RCS dust in the Lesotho mines. This chapter closes by highlighting this study's scholarly contribution and policy impacts.

6. Conclusion

In conclusion, this study underscores the need for more robust health and safety practices in Lesotho's mining industry to effectively protect workers from the risks associated with crystalline silica dust exposure. Despite existing health and safety programs, gaps in training, awareness, and monitoring compromise the effectiveness of these efforts, leaving workers vulnerable to serious respiratory diseases, including silicosis and lung cancer. The findings emphasize that a superficial understanding of dust exposure risks among workers leads to inadequate protective practices, highlighting the necessity of enhanced training and a comprehensive, multi-tiered control approach. Simply relying on personal protective equipment (PPE) and dust suppression mechanisms is insufficient; instead, a hierarchy of controls that includes administrative and engineering measures should be prioritized. Improved knowledge of dust exposure risks among workers could foster more effective practices and help reduce silica-related diseases. As one of the pioneering studies in this context for Lesotho, these findings provide a foundation for potential national policy reform and underscores the need for similar research in comparable African mining environments to develop regionally relevant strategies for reducing occupational dust exposure.

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7. Appendices

7.1 Appendix 1: Plagiarism declaration form

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I **Vuyiseka Langwana** (Student number: **2759995**) am a student registered for the degree of **Master of Medicine :Exposure Science** in the academic year **2024**.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: 06/11/2024

7.2 Appendix 2: Turnitin report

Supervisor: Prof Masilu Daniel Masekameni 

VUYISEKA LANGWANA 2759995 RESEARCH REPORT WRITING-2.docx

ORIGINALITY REPORT

14%	12%	7%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ncbi.nlm.nih.gov Internet Source	2%
2	www.preprints.org Internet Source	2%
3	www.occhealth.co.za Internet Source	1%
4	kipdf.com Internet Source	1%
5	Fatma A. Amer, Hanaa A. Nofal, Manar G. Gebriel, Aya M. Bedawy et al. "Grasping knowledge, attitude, and perception towards monkeypox among healthcare workers and medical students: an Egyptian cross-sectional study", Frontiers in Cellular and Infection Microbiology, 2024 Publication	1%
6	univendspace.univen.ac.za Internet Source	<1%
	pubmed.ncbi.nlm.nih.gov	

7.3 Appendix 3: Similarity Index Letter

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

To: MSc research coordinator/ research committee
School of Public Health

From: Masekameni Masilu Daniel
University of the Witwatersrand
Faculty of Health Science
School of Public Health

RE: Plagiarism report confirmation

I Prof Masilu Masekameni at the capacity of the student supervisor Ms Vuyiseka Langwana at the Faculty of Health Science, University of the Witwatersrand hereby confirming that I have reviewed the research report for similarity index. From my evaluation I can state that the student did not plagiarize in a manner that it reduce the quality of the project. Most similarity index is on common words such as noise, names of authors, action words, silicosis and so on. On another note things like authors names in the reference has been flagged significantly.

Best regards,

Prof Masilu Masekameni
Occupational Health Division
School: Public Health
University of the Witwatersrand
Faculty of Health Science
School of Public Health
daniel.masekameni@wits.ac.za
0795525654

7.4 Appendix 4: AUDA-NEPAD Permission to nest the study into the bigger research study

AUDA-NEPAD
AFRICAN UNION DEVELOPMENT AGENCY

Ms Vuyisika Langwana
Faculty of Health Sciences,
School of Public Health
University of the Witwatersrand

Date: 01 September 2023

To whom it may concern,

Reference is made to your request to nest your master's Research under the African Union Development Agency-NEPAD regional development cooperation baseline study on occupational health and safety. The study under the Southern African Tuberculosis and Health System Support (SATBHSS) project. You are hereby granted permission to use the knowledge, attitude and practice part of the broader study for the purpose of your research study.

We also wish to emphasise that in terms of the original agreement, no names of workers and industries may be revealed. Further, you can publish your study only where this provision is adhered to, and we request the approval of the manuscript by your co-supervisor, Mr Norman Khoza: AUDA-NEPAD: Senior OHS Specialist. This is to ensure that the cooperating agreement and the project multi-sectoral agreement are adhered to even after the end of the SATBHSS project.

We wish you and your mentors the best of luck in your academic journal; we hope your skills will significantly assist the continent in achieving the African Union Agenda 2063, the Africa We Want.

Yours Sincerely

Mrs. Chimwemwe Chamdimba
Head of Institutional Development

230, 15th Road, Midrand, Gauteng, Johannesburg, 1685, South Africa | Tel +27 (0) 11 256 3600 | www.nepad.org

7.5 Appendix 5: Research ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Ms V Langwana

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M231180

NAME: Ms V Langwana **DEGREE:** MSc (Med)
(Principal and Co-Investigators)

DEPARTMENT: School of Public Health
Department of Occupational Health
Medical School
University

PROJECT TITLE: *Workers' knowledge and practices on factors influencing the risk of silica dust exposure in Lesotho mines*

DATE CONSIDERED: Ad hoc

DECISION: Approved unconditionally

CONDITIONS:

NOTE: If contact information regarding student study participants is required, please contact the Registrar's office <Nicoleen.Potgieter@wits.ac.za>

SUPERVISOR: Dr DM Masekameni and Mr N Khoza

APPROVED BY:
Ms M van Niekerk, Co-Chairperson, HREC (Medical)

DATE OF APPROVAL: 28 November 2023 **EXPIRY DATE:** 27 November 2028

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. I agree to submit a yearly progress report in the format available at https://wits.ac.za/research/researcher-support/research-ethics/ethics-committees/. This report is due annually, for the duration of the Clearance Certificate, beginning on the first anniversary of Date of Approval above. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

29/11/2023
Date

7.6 Appendix 6: Questionnaire on Knowledge, attitudes and practices of the participants

Date of Assessment	D	D	M	M	Y	Y	Y	Y

Survey Reference Number								

i. A. COMPANY / SITE INFORMATION

Company Name[1]:	

Size of Mine[2]:		**Number of Years Operating:**	

Primary Commodity:	

Number of Permanent Employees					**Number of Contract Employees**				
Males		Females			**Males**		Females		
Any vulnerable groups?									

B. EMPLOYEE INFORMATION

Gender:	Male	Female	**Age of Employee (Years):**	

Nationality:	

Duration of Employment (Years)[3]:		**Total Period in Mining (Years)[4]:**	

Marital Status:	Single	Married	Divorced	**Highest Level of Education[5]:**	

Type of Job:	Supervisory	Technician	Driver	Equipment Operator	Plant Operator	Labourer	Other

C. HAZARD/RISK IDENTIFICATION / AWARENESS (KNOWLEDGE)

Tick all the hazards below that apply in your work environment.

Rock Falls & Entrapment	☐	Manual Material Handling	☐	Gases & Vapors	☐
Moving Machinery	☐	Methane Gas Explosions	☐	Blasting Fumes & Gases	☐
Fires	☐	Noise	☐	Crystalline Silica Dust	☐
Working at Heights	☐	Heat & Humidity	☐	Coal Dust	☐
Electricity	☐	Ionizing Radiation	☐	Asbestos Fibres	☐
Flooding	☐	Vibration	☐	Diesel Particulate Matter	☐
Microbiological Organisms	☐	Radon Gas	☐	Diesel Exhaust Gases	☐
Malaria	☐	Acids & Caustics	☐	Arsenic, Mercury & Cyanide	☐

D. HEALTH EFFECTS / IMPACTS (KNOWLEDGE)

State whether the statements below are 'True' or 'False' based on your understanding.

	True	False
1. High levels of noise could result in hearing loss or deafness?		
2. Respirable crystalline silica dust can cause silicosis?		
3. Hand-arm vibration is caused by high exposure to vibrating hand tools/equipment?		
4. Exposure to heavy metals such as Mercury and Arsenic can lead to nervous system problems?		
5. High exposure to blasting fumes & gases can lead to carbon monoxide poisoning, especially underground?		
6. Working in areas with high temperatures can lead to heat exhaustion/stroke?		
7. People exposed for long periods to Radon gas have a high risk of developing lung cancer?		

E. HEALTH AND SAFETY POLICIES AND LAWS (KNOWLEDGE)

Answer all questions below as pertaining to your working environment using the responses provided.

	Yes	No	Don't Know	Not Applicable
1. Are there policies and laws regulating mine/occupational health and safety in the country?				
2. Do the occupational health and safety policies and laws demand that employees be trained in health and safety matters?				
3. Does your company have a health and safety policy?				
4. Is the health and safety policy displayed in visible areas in your operation?				

F. CONTROL OF RISKS / RISK FACTORS (KNOWLEDGE)

Answer all questions below as pertaining to your working environment using the responses provided.

	Yes	No	Don't Know	Not Applicable
1. Taking air measurements for dust at the mine is good practice for controlling dust exposures?				
2. Spraying water/chemical agents on travel/haul roads is an effective way to reduce dust levels?				
3. Keeping the dump trucks cabin door closed is a good practice to keep dust levels low inside?				
4. Wearing a dust/paper mask is important when working in dusty areas?				
5. Wearing a dust/paper mask is important when working with chemicals, gases or vapours?				
6. I can protect my hands from workplace hazards/risks by wearing good protective gloves?				
7. Following approved re-entry times after blasting will limit your exposure to dust and blasting fumes/gases?				
8. Wearing hearing protection (earplugs/earmuffs) at work will protect you from going deaf?				
9. I have received health and safety awareness training within the last 12-24 months?				

G. HEALTH AND SAFETY POLICIES (ATTITUDE)

Answer all questions below as pertaining to your working environment using the responses provided.

	Yes	No	Don't Know	Not Applicable
1. I think our work is meant for the brave and not for people who are worried about H&S?				
2. I consider minor accidents as a normal part of my daily work				
3. Health and safety laws are biased against the small scale miners				
4. It is difficult to follow health and safety procedures				
5. Workers react strongly against other workers who break health and safety rules				
6. I feel safe in my work environment?				

H. HEALTH AND SAFETY PROCEDURE (PRACTICE)

Answer all questions below as pertaining to your working environment using the responses provided.

	Yes	No	Don't Know	Not Applicable
1. Does your employer take health and safety seriously?				
2. Do you hold health and safety meetings?				
3. Does your mine check dust and noise on a regular interval				
4. In our mine, we always perform a risk assessment before commencing with work				
5. Do you have a safety representative in your working area?				

I. MORBIDITY / MORTALITY (KNOWLEDGE)

Indicate how you feel about the statements below by answering 'Yes" or 'No".

	Yes	No
Mine dust is the cause of diseases such as pneumoconiosis, silicosis, lung cancer and mesothelioma?		

High levels of dust exposure in mines could be a cause of occupational lung diseases amongst mineworkers?		
Do you think some ex-mineworkers got ill or died due to exposure to crystalline silica or mine dust?		