NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

DEVELOPMENT OF A FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA

by

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Health Sciences in the Faculty of Health, Natural Resources, and Applied Sciences

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Date: January 2025

Declaration

I, Saima Shihepo, hereby declare that the work contained in the thesis entitled "Development of a Framework for the Protection of Quarry and Allied Workers from Occupational Respiratory Infections in Namibia" is my original work and that I have not previously, in its entirety or in part submitted the thesis at any university or higher education institution for the award of a degree.

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Dedication

I dedicate my research study to my family and friends. Gratitude goes to my daughter, Tameka Ayvah Wombulu, for showing immeasurable love and support during this study.

List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
CSIR	Centre for Scientific and Industrial Research
FFRs	Filtering Facepiece Respirators
HBM	Health Belief Model
ILO	International Labour Organisation
KPA	Knowledge, Attitudes, and Practices
NNHPF	Namibian National Health Policy Framework
MOHSS	Ministry of Health and Social Services
MOLSW	Ministry of Labour and Social Welfare
NIOSH	National Institute for Occupational Safety and Health
NUST	Namibia's University of Science and Technology
OHS	Occupational Health and Safety
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air Purifying Respirator
PFEEM/F	Particle Filtration Efficacy Experiment of Masks/Filters
PFE	Particle Filtration Efficacy
PSA	Particle Size Analyser
PPE/C	Personal Protective Equipment/Clothing
QNFT	Quantitative respirator fit test
QLFT	Qualitative fit testing
SMEs	Small and Medium-sized Enterprises
RPP	Respiratory Protection Program
TPB	Theory of Planned Behaviour
TTM/SOC	Transtheoretical Model/Stages of Change Model
WHO	World Health Organisation

Definition of Terms

Administration controls are workplace guidelines and protocols implemented to reduce or minimise worker exposure to respirable dust.

Attitudes refer to quarry and allied workers' thinking and general feelings towards respiratory protection.

Engineering controls are physical modifications implemented in a work environment to eliminate or minimise one's exposure to respirable dust

A framework is a methodical or standard approach for managing processes, personal safety, and operational credibility, ensuring continuous improvement on all safety aspects

Hierarchical hazard control is an approach to identifying and ranking methods that safeguard employees from respiratory hazards

Knowledge refers to quarry and allied workers' awareness of facts and information about respiratory protection.

Particle filtration efficiency is a laboratory experiment measuring the effectiveness of masks/filters used by workers for protection from respirable dust.

Personal Protective Equipment/Clothing forms wearable material providing direct protection or restriction from respiratory hazards.

Practices refer to the actions of quarry and allied workers relating to respiratory protection.

Respirable dust particles (less than 10µm in diameter) that penetrate the body's natural defence reach the alveoli.

Respiratory infections are the inflammation of the mucus membrane of the respiratory system caused by viruses or bacteria.

Respiratory protection safeguards employees against occupational respiratory hazards or respirable dust.

Abstract

Background: Workplace frameworks ensure compliance with fundamental Occupational Health and Safety (OHS) legal provisions, effectively reducing workplace accidents and illnesses. Namibia lacks a comprehensive respiratory framework for protecting high-risk workers in quarry and allied industries. This study aimed to develop a respiratory protection framework that safeguards quarry and allied workers who are susceptible to occupational respiratory diseases in Namibia.

Methodology: A phased methodological approach was adopted in the study, which involved mixed methods (qualitative and quantitative) experimental techniques and secondary data review. Phases 1 and 2 assessed existing respiratory protection practices by quarry and allied workers and their knowledge, attitudes, and practices on occupational respiratory protection, respectively. This was conducted through self-administration of 320 questionnaires to workers, using a multi-tier sampling technique, as well as interviewing the managerial staff. Phase 3 involved a laboratory assessment of the Particle Filtration Efficiency (PFE) of N95 masks used by the workers. Phase 4 reviewed the Namibian legal provisions aligned with respiratory protection. Premised on the study findings, a respiratory protection outline was proposed, addressing gaps in policy and practice in phase 5.

Results: Characteristics and variables such as age, gender, work experience, beards, level of education, knowledge (training) of respiratory protection hazards, and risk perceptions of respiratory protection exacerbate the workers' risk of respirable dust inhalation. Results revealed that about 69.7% of the quarry and allied workers currently experience respiratory protection. However, 66.8%, 57.2%, and 69.7% have inadequate respiratory protection knowledge, negative attitudes, and poor protective practices, respectively. Three (3) themes were identified: One (1). Employee knowledge of respiratory protection. Two (2) Employee attitudes aligned with respiratory protection and three (3) Employee practices on respiratory protection. The Particle Filtration Efficiency (PFE) gravimetric weighing had minimal dust retention, with higher dust exposure at Sites C, D, F, and G. Particle size analysis revealed that most masks failed to effectively filter smaller particles below PM_{10}. Reduced mask efficacy due to membrane saturation was also recorded after prolonged use. Sites A, B, and C demonstrated PM_{10} particle retention at 100%, while Site D showed only 60%. The review of Namibian legal provisions protecting quarry and allied workers showed fragmentation and no clarity on implementation, thereby ineffectively protecting the workers. Guidelines to operationalise the framework were developed based on the study findings obtained through questionnaires from workers, interviews from management, Particle Filtration Efficiency (PFE) experiment results, and the review of Namibian legal provisions. The framework was evaluated by experts in academia, occupational health professionals, and industry stakeholders to assess each framework component's relevance, clarity, and completeness.

Conclusion: This study underscores substantial gaps in respiratory protection, knowledge, attitudes, and practices among quarry and allied workers in Namibia, contributing to increased exposure to respirable dust and associated health risks. The inefficacy of the N95 masks used by workers in filtering fine particulate matter of Particulate Matter PM_{10} further emphasised the critical need for a robust respiratory protection framework. Furthermore, the fragmented and unclear legal provisions fail to offer adequate protection for high-risk workers. Based on these findings, the proposed respiratory protection framework provides a comprehensive approach to improving workplace safety through enhanced policies, effective training programmes, and the adoption of higher-efficiency respiratory protective equipment. Implementing this framework is crucial for safeguarding workers' health and ensuring long-term occupational safety in Namibia's quarry and allied industries.

Key Words: Framework, Occupational Health and Safety, Quarry and Allied Workers, Respiratory Protection, Particle Filtration Efficiency, Filters/Masks.

CHAPTER 1: INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 Introduction to the Study

Occupational respiratory illnesses are among workers' most significant global health challenges in high-risk industries. Quarry and allied workers are particularly vulnerable due to prolonged exposure to respirable dust, which increases the risk of conditions such as silicosis, chronic obstructive pulmonary disease (COPD), and other respiratory infections. Despite advancements in occupational health and safety (OHS) globally, these illnesses remain a persistent issue, especially in countries with limited regulatory enforcement and inadequate frameworks for workplace safety (Vanka et al., 2022). The magnitude of the global impact of occupational accidents and diseases, as well as major industrial disasters, in terms of human suffering and related economic costs, has been a long-standing source of concern at the workplace, national, and international levels. Significant efforts have been made at all levels to come to terms with this problem. Still, Nevertheless, ILO estimates are that over 2 million workers die each year from work-related accidents and diseases, and that globally this figure is on the increase. OSH has been a central issue for the ILO ever since its creation in 1919 and continues to be a fundamental requirement for achieving the objectives of the Decent Work Agenda (ILO, 2003). In Africa, Adeyemo and Smallwood (2017) identified some problems affecting OHS legislation implementation within the construction industry. These problems included limitations in the OHS legislation, bribery and corruption, inadequate funding of facilities and equipment, high levels of insecurity, poor OHS culture among construction stakeholders, and the severity of penalties to offenders. Occupational health and safety (OHS) in Namibia faces challenges including low awareness, poor compliance with regulations, limited resources, and a lack of dedicated OHS professionals, particularly in the informal sector and construction industries. Furthermore, construction work is dynamic with working environment changes, poor working conditions, poor working environment and workers being exposed to several hazards such as noise, dust, vibration, and poor ergonomic conditions. (Pinto et al., 2011).

A national regulatory framework comprises all the infrastructures, mechanisms, and specialised human resources required for the practical implementation of national Occupational Safety and Health (OSH) legislative programs. According to Brockmeyer (2016), national OSH legal framework programs aim to strengthen national OSH systems by responding to the effects of both socioeconomic and technological changes on working conditions and the environment. The effective institution of occupational regulatory frameworks has been hampered by the inevitable time lag between changes in the world of work or the detection of new hazards and risks, and the development and implementation of appropriate responses. The traditional strategies and methods for prevention and control need radical updating to respond effectively to the fast and continuous changes in the workplace (Arstad & Aven, 2017). To be successful, the development of appropriate responses must make use of the collective body of knowledge, experience, and good practice in this area. Therefore, to ensure satisfactory and durable results in occupational safety and health, each country should put in place a coherent regulatory framework (Long et al., 2015). Such a regulation should be aimed at promoting and advancing at all levels the right of workers to a safe and healthy working environment; at assessing and combating at-source occupational risks or hazards; and at developing a national preventive safety and health culture that includes information, consultation, and training (Sanmiquel, et al., 2015). Mechanisms and strategies must therefore be developed to keep occupational safety and health continuously at the forefront of national and enterprise priorities.

The absence of a detailed occupational health and safety framework tailored to quarrying and allied industries has increased the risk to workers' health. While general Occupational Health and Safety (OHS) provisions exist under the Labour Act No. 11 of 2007, they do not address the unique challenges of dust-intensive industries. This study aimed to develop a framework that safeguards quarry and allied workers from occupational respiratory infections, bridging critical gaps in policy and practice to enhance worker protection.

1.2 Background of the Study

Workplace hazards deprive societies, organisations, and families of valuable resources, including human lives, economic stability, and social well-being. Hence, organisational leaders need to improve occupational safety and health initiatives. Leaders need to develop shared priorities for informing collaborative surveillance, research, and interventions in the form of frameworks (Brinker et al., 2016). Blanc and Seaton (2016) reiterate that quarry mining and allied industries attempting to improve safety and health performance mainly focus on developing occupational health frameworks. Carter (2016) defines a framework as a standard approach for managing processes, personal safety, and operational credibility, ensuring continuous improvement in all safety aspects. According to Ivensky (2016), frameworks in Occupational Health Safety (OHS) are methodical ways of managing safety risks by implementing adequate controls and adequately training and empowering employees in work processes, designing and operations that deliver consistent safety and health performance.

In addition, frameworks, according to Geng & Saleh (2015), are necessary for assuring compliance with fundamental norms as they have been utilised to avoid workplace accidents and illnesses as effective instruments. Eshiwani (2014) reports that a framework reinforces the commitment to providing a safe working environment while allowing it to meet moral and international duties. Notwithstanding, Ivensky (2016) opined that Governments frequently use frameworks to design and adopt regulations, rules, and laws. Hence, regulatory frameworks are important legal mechanisms that exist at the national or international levels to ensure compliance with contractual obligations, codes, and conduct, among others. At workplaces, the regulatory framework constitutes a system of checks and balances that ensures adherence to regulations by employers and, thus, the protection of workers' health.

1.3 Problem Statement

Traditional methods of preventive and control strategies for occupational health (respiratory) conditions need to be radically updated to successfully adapt to the rapid and constant changes in the workplace (Arstad & Aven, 2017). The unavoidable time lag between the identification of new hazards and risks, as well as the creation and execution of suitable solutions, requires constant checks on the occupational framework (Long et al., 2015). The creation of suitable solutions must consider the collective body of knowledge, experience, and good practice in this field to succeed. Therefore, each country should establish a consistent framework to achieve satisfying and long-term outcomes in occupational safety and health (Arstan & Aven, 2017)

The regional OHS framework for Sub-Saharan Africa and East Asia, developed by the World Health Organisation (WHO), is important for formulating national policies and action plans. Subsequently, several African nations have developed national strategies and action plans, national profiles, and occupational health programs (ILO, 2013). However, Sub-Saharan African nations, including Namibia, are renowned for having outdated OHS laws and a lack of legislative standards, thus signalled by an insufficient guiding framework. Namibia's present occupational health and safety framework was established in 2007, focusing on general workplace health and safety. This makes national attempts to combat occupational respiratory diseases disjointed and ineffective (Gordis, 2013). In Namibia, there is no primary OHS framework. The only OHS legislative framework that is in place is as reflected in the Labour Act No. 11 of 2007, chapter 4, as well as under the Labour Act No. 6 of 1992, which reflects regulation on the health and safety of employees at the workplace (NPOSH, 2013/2014). This Act only specifies the responsibilities and duties of employers in providing OHS to ensure the health and safety of employees at work (Nghitanwa, 2016). In addition, the regulation has not been reassessed for its effectiveness and applicability in the past 14 years. Therefore, it might not address and safeguard employees from occupational respiratory health and safety using appropriate current techniques. Currently, there is the Labour Act and OHS Safety Act; however, no guiding framework provides an organisational framework or outline that addresses all occupational health and safety problems in diverse workplaces.

This leaves a vacuum in the protection of employees, particularly among the work sectors in which workers are predisposed to respiratory diseases, such as the Allied and Quarry workplaces. This vacuum is rising in Namibia due to increased mining and industrial activities, and reported health problems arising from occupational hazard exposure. Therefore, this study sought to develop a framework to cope with and safeguard quarry and allied workers agonised in occupational respiratory diseases in Namibia.

1.4 Compliance with Occupational Health and Safety Legislation

Compliance is the process of observing requirements set by employers and workers to prevent occupational accidents, injuries, diseases, and fatalities. Compliance assists in establishing efficiency, effectiveness, and safety during work performance (Zin & Ismail, 2015). In this study, compliance refers to the obedience, acceptance, and practice of health and safety measures in quarry industries (Al-Bayati, 2023). Globally, the quarry mining and construction industries are rated as the worst performers among other industries, as far as occupational health and safety are concerned, because of their propensity for high injuries and fatal accidents (Health and Safety Executive Report, 2014).

Literature indicates that employers' ignorance of the ILO's legal guidelines on occupational health and safety at workplaces exposes workers to occupational injuries. In addition, employers' negative attitudes and ignorance toward OHS practices also contribute to high rates of injuries in the construction industry (Gürcanl et al., 2015). The study also pointed out that workers tend to compromise OHS due to workplace designs or work overload, which may affect their behaviour towards OHS and lead to more workplace accidents. Occupational Health and Safety should be discussed and implemented by both management and workers for the good maintenance of management and workers to maintain health and safety culture in the organisation.

A groundwork study among quarry workers in Edo State, in southern Nigeria, showed a deficiency of awareness of the hazards and diseases related to working in the quarry industry and poor use of safety equipment, which might suggest some level of poor compliance (Isara, Adam, Aigbokhaode, & Alenoghena, 2016). Quarries must be adequately inspected and maintained to ensure the health and safety of all on-site workers. Another study conducted in Zaria, Nigeria, on the assessment of awareness and compliance with safety measures and the use of protective devices suggests partial compliance with safety measures in the establishment (Tuktur, 2017).

Developed countries such as China are highly compliant with OHS legislation, with their health and safety committees, and representatives nominated to ensure safety on-site and present workers in trade unions (Ivensky, 2016). It has been noted that a lack of commitment within management, poor supervision, and an absence or inadequate training led to poor OHS management and non-compliance in the construction industry (Brockmeyer, 2016). Thailand strengthens its country's OHS compliance in construction companies through the requirement that companies must submit, during tendering processes, their safety management programs in construction, stating how accidents and injuries would be prevented during construction work and indicating how compliant they would be to OHS (Gürcanl, Baradan, & Uzun, 2015). Similarly, construction companies in Japan with poor safety records are penalised and prohibited from tendering (ILO, 2013).

Legal frameworks for the operationalisation of OHS can be established globally. The frameworks such as the Health and Safety Executive in the UK, the Japan Industrial Safety and Health Association (JISHA), and the USA's Occupational Safety and Health Administration (OSHA) in the USA reinforce compliance with the health and safety legislation at the workplaces and Occupational Health Acts in several developed countries (Zhou, Whyte, & Sacks, 2014). At times, employers and workers do not adhere to the stipulated requirements, and as a result, the number of accidents and fatalities in the construction industry has been increasing (Zin & Ismail, 2015).

1.5 Role and Relevance of Occupational Framework

Given the complexity and extent of occupational safety and health problems and the many sources of occupational hazards and work-related diseases, no single intervention would be sufficient to constitute an effective OSH program. The practical measures adopted may vary, depending on the degree of technological, economic, and social development of the country concerned and the type and extent of the resources available. It is possible, however, to provide or recommend a broad outline of the essential components of a framework (Zhou et al., 2014).

The primary focus of the framework is on fostering a safe and healthy work environment and safe work systems (Gürcanl, Baradan, & Uzun, 2015). The main principle is the creation of a safe work environment by eliminating or controlling risks that may result in the development of occupational health conditions and diseases. Thus, preference is given to measures that make the work environment safer (safe place controls) over individual measures (safe person measures) (Geng & Saleh, 2015).

Formulating a framework, outline, or scheme reflects the respective functions and responsibilities of public authorities, employers, workers, and others, and should recognise the complementary character of those responsibilities. A legislation framework regulates employers and workers by stating the required status, setting up the rules and regulations, and imposing punishment in case of a breach of regulations (Zhang et al., 2016). However, legislation is only helpful when it is followed and adhered to. Therefore, the management of a construction site adheres to the legislation by enforcing OHS to ensure protection at their worksites and prevent injury.

Globally, respiratory conditions rank high among reasons for patients seeking care at primary healthcare facilities and account for up to one-third of patients seen at these facilities (A Abdel et al, 2023). Occupational chronic respiratory diseases in low- and middle-income countries, such as Namibia, present a public health problem with substantial economic implications (Nghitanwa, 2016). Preventing such diseases is, therefore, extremely important. In Namibia, occupational safety, health, and welfare are provided for in Chapter 4 of the Labour Act 11 of 2007. The legal framework deals with the rights and duties of employers, employees, and the provisions concerning health and safety representatives and joint OSH committees (Government of the Republic of Namibia, 2007). However, the provisions for occupational safety and health in the mining sector, particularly quarry mines, and particularly regulations concerning dust control in the work environment, are very general and leave room for interpretation.

Although several national programs are implemented in Namibia to prevent and reduce occupational respiratory conditions, these appear to be ineffective. There is a lack of a framework that addresses the establishment of a sustainable and integrated system that accommodates occupational respiratory health. Other complementary frameworks, such as the Namibian National Health Policy Framework, are silent on occupational respiratory conditions, as they emphasise clinical and public health respiratory conditions compared to the private sector, where most quarries operate (MoHSS, 2022). Therefore, in line with this, there is a need to move towards area-specific approaches, such as a framework in occupational respiratory health, as an effective and integrated prevention and control program approach to challenge the high prevalence of occupational respiratory conditions in quarry mines.

Namibia does not have provisions for a legal framework that requires submitting a health and safety plan during the tender application. This is cause for concern as there would be no indication or guarantee that the construction companies will comply with occupational health and safety requirements after the tenders are awarded (Nghitanwa, 2016). Nonetheless, occupational health and safety practices in Namibia are enforced by occupational health and safety inspectors from the Ministry of Labour and Social Welfare through regular inspections of construction sites and communication with workers and employers regarding OHS requirements. The labour inspectors reported that most industries in Namibia, including the construction sector, are noncompliant with

OHS legislation. Only 10% of the workplaces inspected during the 2015/2016 financial year complied with OHS legislation (MoHSS, 2022).

1.6 Theoretical and Practical Significance of the Research Study

Studies on the protection of quarry workers and allied workers from respiratory infections are limited, particularly in Namibia. This gap highlights the critical need for a tailored framework to address the unique challenges faced by these workers.

The significance of this study lies in its contribution to filling this knowledge gap by providing an evidence-based framework that integrates global best practices with Namibia's socio-economic and industrial context. This study addresses the absence of a framework for respiratory infections, aiming to protect quarry workers and allied workers from respiratory infections. Due to their small number and the low capital base, these informal entrepreneurs cannot afford pre-entry or periodic medical examinations, which are essential in identifying those most likely to be affected.

Furthermore, the study highlights the economic and health burden posed by the lack of pre-entry and periodic medical examinations among informal entrepreneurs. These examinations are essential for the early detection and prevention of occupational respiratory diseases. By developing a framework that incorporates occupational risk assessments and hazard characterisation, this study provides a practical roadmap for mitigating these risks.

Therefore, the findings will contribute to the body of knowledge by 1. Establishing baseline data on respiratory health conditions among quarry and allied workers in Namibia, demonstrating the effectiveness of integrating engineering controls, administrative controls, and personal protective equipment within a unified framework, and 3. Highlight key stakeholders' roles and responsibilities in improving workplace safety standards, including policymakers, employers, and workers.

The study's recommendations aim to bridge the gap between policy and practice by advocating for mandatory health and safety plans, regular medical surveillance and targeted educational interventions. These contributions not only advance scholarly understanding of occupational respiratory health but also offer actionable solutions to enhance compliance and safeguard vulnerable worker populations in Namibia. The findings from the research may serve as the basis for further analysis on the development of a framework for the protection of workers from occupational respiratory infections in Namibia and other developing countries.

The study findings will contribute to the growing debate on knowledge, attitudes, and practices on the protection of workers from occupational respiratory infections in Namibia and other developing countries. Environmentalists and health-related scholars will make use of the information contained herein as a reference point in addition to the available literature.

1.7 Aims/Purpose of the Research

The study aimed to develop a theoretical framework for the protection of quarry and allied workers from occupational respiratory infection in Namibia.

1.7.1 Research Objectives

1. Assess the current practices in protecting quarry and allied workers from respiratory infections.
2. Evaluate the quarry and allied workers' knowledge, attitudes, and practices on occupational respiratory protection.
3. Measure the particle filtration efficiency of the masks/filters used at quarry mining sites.
4. Examine, by review, the Namibian legal provisions protecting quarry and allied workers from respiratory infections.
5. Develop a framework that guides the protection of quarry and allied workers from occupational respiratory infections.

1.7.2 Research Questions

1. What are the current practices for protecting quarry and allied workers from respiratory infections?
2. What is the level of knowledge, attitudes, and practices (KPA) of quarry and allied workers regarding occupational respiratory protection?
3. What is the particle filtration efficiency for the different types of masks/filters used at mining sites?
4. How do the current Namibian legal provisions protect quarry and allied workers from respiratory infections?
5. How does the framework aid (the role played by the framework) in protecting quarry and allied workers from respiratory infections?

1.8 Structure of the thesis

This research report is structured and organised into six chapters, which are outlined as follows:

Chapter 1 provides the introduction, background information, and an overview of the study. It also outlines the statement of the research problem, the aim of the study, the objectives, research questions, and the significance of the research.

In Chapter 2, the reviews of relevant literature aligned with developing a framework for protecting quarry and allied workers from occupational respiratory infections. It discusses global and national perspectives on respiratory health, theoretical frameworks, and existing occupational health and safety practices, highlighting gaps in the current knowledge base.

This study setting, study population, and research design are described in **Chapter 3**. It details the sampling procedures, data collection, and analysis approach. Additionally, ethical considerations, trustworthiness, validity, and reliability are discussed in detail as part of the methodology for this study.

In Chapter 4, the study's findings, including quantitative and qualitative results, are presented. Key areas include respiratory protection practices, knowledge, attitudes, and practices (KAP) among quarry and allied workers and the efficacy of protective equipment and legal frameworks.

Furthermore, **Chapter 5** discusses the results in relation to research objectives and existing literature. It analyses key findings in-depth, exploring their implications for occupational health and safety policies and practices. The discussion also identifies areas for improvement and potential solutions.
In **Chapter 6,** the framework is outlined for utilisation by the quarry and allied workers workplace program, which will be derived from the study findings.

Lastly, the Conclusion, study limitations, novelty/ Unique contribution to Knowledge and Recommendations are discussed in **Chapter 7.**

1.9 Chapter Summary

This chapter provided an overview and background of the problem from an international level to the Namibian context. The problem statement highlighted the study's aim, objectives, and significance. The next chapter presents a detailed review of relevant literature, focusing on global and national perspectives on occupational respiratory health, theoretical frameworks, and existing practices in protecting quarry and allied workers.

CHAPTER 2: CONCEPTUAL/ THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of relevant literature aligned with the development of a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. The first part describes the study's various theoretical frameworks, followed by the protection of quarry and allied workers on respiratory conditions and their knowledge, attitudes, and practices on respiratory protection.

2.1 Philosophical Basis of the Study

The pragmatic philosophy is the underlying perspective guiding the process and understanding of this study. Pragmatism is originally derived from the Greek word "pragma," which means action. The pragmatist philosophy holds that human actions are inseparable from past experiences and related beliefs (Priya & Susweta, 2015). A major underpinning of pragmatist philosophy is that knowledge and reality are based on beliefs and habits that are socially constructed; hence, experience is desirable to ascribe meaning (Bunniss & Kelly, 2015). In this study, pragmatism uses quarry and allied workers' experience as the primary means for building knowledge and understanding of the current practices in protecting them from respiratory infections and evaluating their KPA on respiratory protection.

According to Dieleman, Rondel, and Voparil (2017), the pragmatic theoretical position is nestled between positivism and interpretivism, which are two highly exclusive perspectives about the nature and sources of knowledge. With modified philosophical assumptions, pragmatism combines positivist and interpretivist positions within the scope of a single research. Kaushik and Walsh (2019) contend that pragmatism rejects the traditional philosophical dualism of objectivity and subjectivity and allows the researcher to abandon the forced dichotomies of positivism and constructivism. Therefore, rather than assigning positivism and constructivism, pragmatism allows the researcher to focus on the two different approaches to inquiry. That is, the pragmatic philosophy provided a middle position both methodologically by offering a mixed-methods approach with both positivist and constructivist perspectives aligned to respiratory protection inquiries.

Long, McDermott, and Meadows (2018) remark that pragmatism emerges from the efforts to focus on solving practical problems in the real world through inquiry. In so doing, pragmatism seeks to address practical issues arising directly from communities using the most appropriate methods. Hill (2017) argues that social problems are best defined by the individuals experiencing them. Based on this notion, quarry and allied workers form a community troubled by occupational respiratory conditions and infections. Therefore, to understand respiratory problems, individual quarry and allied workers' KAP on respiratory protection and their level of security are evaluated.

Focusing on practical thinking and action, a pragmatic stance creates a theoretical sound that applies to real-world settings. Hogg and Vaughan (2015) complement the pragmatic philosophy in healthcare research and consider the broader social, cultural and political contexts that shape health and healthcare. In this study, assuming the pragmatic perspective allows for the application of respiratory protection knowledge, leading to the practical development of a framework that guides the protection of quarry and allied workers from occupational respiratory infections.

2.1.1 Paradigmatic Assumptions

The study follows the following paradigmatic assumptions:

2.1.1.1 Ontology

Ontology describes how the researcher perceives reality and the nature of human engagement in the world (Scotland, 2017). Maxwell (2016) believes that ontology focuses on existing features of truth and reality, which can be objective or subjective. An objective view considers reality to be external to the researcher's mind, while a subjective view defines reality as created in the mind of the social actor. Objective reality is assumed to be independent of the minds of social actors (Hill, 2017). Depending on the worldview of social phenomena, reality can be viewed from the realist or nominalist ontology for objective and subjective perspectives, respectively. Realist ontology holds that there should be a single reality that all the concerned social actors should discover. The nominalist ontology is associated with multiple realities as created in the minds of various social actors (Morgan, 2016). Scotland (2017) states that nominalism is associated with using flexible methods, unlike realist ontology, which uses specific methods in specific situations. In this study, the nominalist ontological stance shapes multiple beliefs and realities centred around the protection of quarry and allied workers from respiratory conditions and infections. For example, in this study, the social constructivist nominalist ontological position assumes that KAP associated with respiratory conditions and infections are social constructs shaped by cultural and social factors. The focus is directed on understanding the KAP of quarry and allied workers on occupational respiratory protection. Individual KAPs are key social constructs of reality critical to respiratory protection.

2.1.1.2 Epistemology

Epistemology describes how knowledge about reality is acquired, understood and utilised. (Derek, 2023). According to Howell (2016), epistemology is interested in learning about the phenomena of interest. Long, McDermott and Meadows (2018) add epistemology that clarifies the possibilities of knowledge origin, structure, methods and how this knowledge can be obtained and confirmed. The epistemological stance of healthcare researchers refers to their fundamental beliefs about knowledge and how it can be acquired. There are several epistemological stances that researchers may take, including positivism, interpretivism, critical theory, and pragmatism

2.1.1.2.1 Positivism

Positivism is grounded in the idea that knowledge can be gained through objective observation and measurement (Bergmann, 2024). Using this positivism philosophical approach, the researchers express their views to assess the social world, and instead of subjectivity, they refer to objectivity (Dieleman, Rondel, & Voparil, 2017). Under this paradigm, researchers are interested in general information and large-scale social data collection. In line with this position, the researchers' attitudes are irrelevant and do not affect scientific research. The positivist philosophical approach is most closely associated with the observations and experiments used for the collection of numerical data (Hothersall, 2019). Adopting the positivist stance created a measurable and replicable research laboratory experiment and a survey.

2.1.1.2.1.1 Laboratory Experiment

According to Gordis (2013), laboratory experiments permit the researcher to identify precise relationships between a small number of variables studied intensively via a designed laboratory situation using quantitative analytical techniques to make generalisable statements that apply to real-life situations. This study’s experiment assessed the particle filtration efficiency of the different types of masks/filters used at mining sites. The PFE test evaluated the nonviable particle retention, that is, the impact of filters on protecting quarry and allied workers from respiratory conditions and infections.

2.1.1.2.1.2 Survey

A survey enabled the researcher to obtain data on the KAP of quarry and allied workers on respiratory protection at one point in time through questionnaires. Quantitative analytical techniques such as Pearson correlation and multiple regression analysis were used to draw inferences regarding existing relationships of knowledge, attitudes and practices and from socio-demographic characteristics (Saunders, Lewis, & Thornhill, 2016). The use of surveys permitted the researcher to study more variables at one time in a real-world environment.

2.1.1.2.2 Constructivism

This epistemological perspective is based on the belief that knowledge is constructed through human interpretation and social interactions. (Long, McDermott, & Meadows, 2018). Adopting the constructivist stance sought to understand the subjective experiences of managerial staff and the meanings they attach to their experiences. Eliciting managerial staff experiences, narratives and perspectives on quarry and allied workers on respiratory protection used qualitative methods

2.1.1.2.3 Axiology

Axiology explains the role and importance of the research process, considers the values researchers assign to their research, and guides their pursuit of knowledge (Ryan, 2018). Thus, axiology is concerned with the values of the researcher on aesthetics and ethics by examining issues of right and wrong and measuring the level of development and types of biases (Yilmaz, 2013). Hill (2017) believed that the philosophical concept of axiology is important in making research choices by considering the roles that values play in a particular knowledge-generation process and the capability of researchers to make value judgments. Therefore, the quality of knowledge generated is influenced by the awareness and control of values in the study through self-regulation.

In this study, the axiological stance is premised on values, beliefs, and ethical positions that guide the research practices and interpretations of findings. The study embraced the health equity value, which emphasises the importance of addressing health disparities and promoting fairness and justice in healthcare (Derek, 2023). For instance, the researcher investigated quarry and allied workers, who can be regarded as an underrepresented group of people regarding respiratory protection, since formal organisations are the ones that are mostly recognised and receive protection. Also, the value of evidence-based practice stresses the best available evidence to guide decision-making and formulation of health prevention strategies (Priya & Susweta, 2015). The development of the respiratory framework is an evidence-based process deduced through the study outcomes; it is designed to suit the Namibian context and will be effective and responsive when applied in controlling and preventing respiratory conditions and infections among quarry and allied workers.

2.1.1.2.4 Research Approach

Methodology is the strategy or action plan that informs the choice and use of particular methods within the context of a particular research paradigm (Bergmann, 2024). Researchers' methodological stance in healthcare refers to their underlying beliefs and approach to conducting research in this field. The main types of methodology include quantitative and qualitative research. Mixed-method research was used to develop a framework for protecting quarry and allied workers from occupational respiratory infections in Namibia. The mixed method emphasises the use of multiple methods and the importance of adapting research to specific contexts and goals (Bunniss & Kelly, 2015). A pragmatic approach encourages researchers who use different methods in different paradigms to emphasise shared meanings and pursue joint action (Kaushik & Walsh, 2019). The quantitative approach patterned and quantified the level of employee respiratory protection and the level of KAP towards respiratory. Quantitatively, the relationships between employee respiratory protection and work-related and individual factors were established. The qualitative approach will enable the researcher to gain an in-depth understanding and create a more comprehensive insight into respiratory protection compliance levels and current practices in the working environment of quarry and allied workers.

2.2 Theoretical Framework

The theoretical framework provides a roadmap for a better understanding of elements that protect quarry and allied workers from occupational respiratory infections. This section presents different theoretical models and frameworks used in similar studies. The first part discusses three theoretical models and frameworks, which include the Health Belief Model (HBM), the Theory of Planned Behaviour (TPB) and the Transtheoretical Model/Stages of Change Model (TTM/SOC).

2.2.1 Health Belief Model (HBM)

The health belief model (HBM) can be used to explain preventive behaviours and reactions to a disease or health condition by people. The model postulates that individual health behaviour results from perceptions, modifying behaviour and the likelihood of action (Ajzen & Fishbein, 2007). Derek (2023) holds that the HBM investigates and identifies factors related to health beliefs from an individual's point of view, such as personal preventive behaviours and attitudes towards respiratory protection and self-health management. The HBM focuses on four key constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers and self-efficacy. Hill (2017) describe perceived susceptibility as the personal perception of the subjective risk of being affected by a condition or infected with a specific disease. In this study, perceived susceptibility is the quarry and allied worker's believed risk level of being affected by respiratory diseases or conditions. Perceived severity means personal perceptions and feelings about suffering from a disease (Hill, Fishbein, & Ajzen, 1997).

In this context, perceived severity entails that quarry and allied workers, as well as managerial staff, believe that the outcome of respiratory diseases or conditions is severe. Hence, safety solutions and policies will enhance the perceived severity among employees and create a workplace with a more favourable safety climate where employees present high levels of respiratory hazard identification and safety risk awareness (DiClemente et al., 1994). According to Hogg and Vaughan (2015), perceived benefits are adopted to reduce disease threats effectively and reflect personal thoughts on improving safety measures. In this study, perceived benefits mean that quarry and allied workers believe respiratory health preventive behaviours can reduce the risk or severity of respiratory diseases or conditions. Organisations with proper respiratory protection programmes increase the perception of not being affected or infected with respiratory diseases or conditions. Priya and Susweta (2015) pronounce perceived barriers as potential setbacks in the process of respiratory prevention behaviours, as subjectively assessed by an individual. In this study, quarry and allied workers believe that performing respiratory prevention behaviours will be limited by individual and organisational factors. In this study, self-efficacy means the level of confidence that quarry and allied workers have in adopting respiratory prevention behaviours (Guerin & Sleet, 2021). Under a good safety climate, organisations have specific respiratory safety goals, strategies and methods for goal implementation.

Hill, Fishbein and Ajzen (1997) reiterate that the HBM explains the conditions under which a person will engage in individual health behaviours such as preventative screenings or seeking treatment for a health condition. In this study, the HBM helps explain workers' respiratory safety behaviour as it emphasises perceived susceptibility as one of the influencers of behaviour in a workplace. The quarry and allied workers' personal perception and behaviour toward respirable dust exposure play a pivotal role in their health, and individual workers are presumed to experience difficulties with breathing in a work environment where airborne particles are constantly present. The HBM is key in designing respiratory protection interventions through a framework that enables individual workers and employers to make healthy decisions.

2.2.2 Theory of Planned Behaviour (TPB)

This study assumes the theory of planned behaviour (TPB) as one of the theoretical frameworks applied to quarry and allied workers in predicting safe and unsafe respiratory prevention behaviours. The TPB was proposed by Ajzen, extending from the Theory of Reasoned Action (TRA), explaining numerous behaviours in specific contexts (Ajzen & Fishbein, 2007). The model assumes that behaviour is planned; hence, it provides guidelines that help examine individuals' beliefs and behaviour. The TPB depicts intention through three psychological drivers: attitudes, subjective norms and perceived behavioural control (Hogg & Vaughan, 2015). Thus, attitudes, subjective norms, and perceived behavioural control are proximal determinants in exhibiting safety behaviour. Priya and Susweta (2015) describe attitudes as the degree to which a person exhibits a favourable evaluation of the behaviour. Subjective norms are perceived social pressure to perform the behaviour, whereas perceived behavioural control entails the perceived ease to perform the behaviour of interest (Yilmaz, 2013). Hence, the intention of displaying safe respiratory behaviour or action is determined by the quarry and allied workers' attitude towards safe behaviour, social influences or beliefs of respiratory protection, and the ease or difficulty of engaging in safe respiratory behaviour. Behavioural outcomes can be positive (safe) or negative (unsafe). Unsafe behaviour contributes to occupational respiratory diseases and conditions.

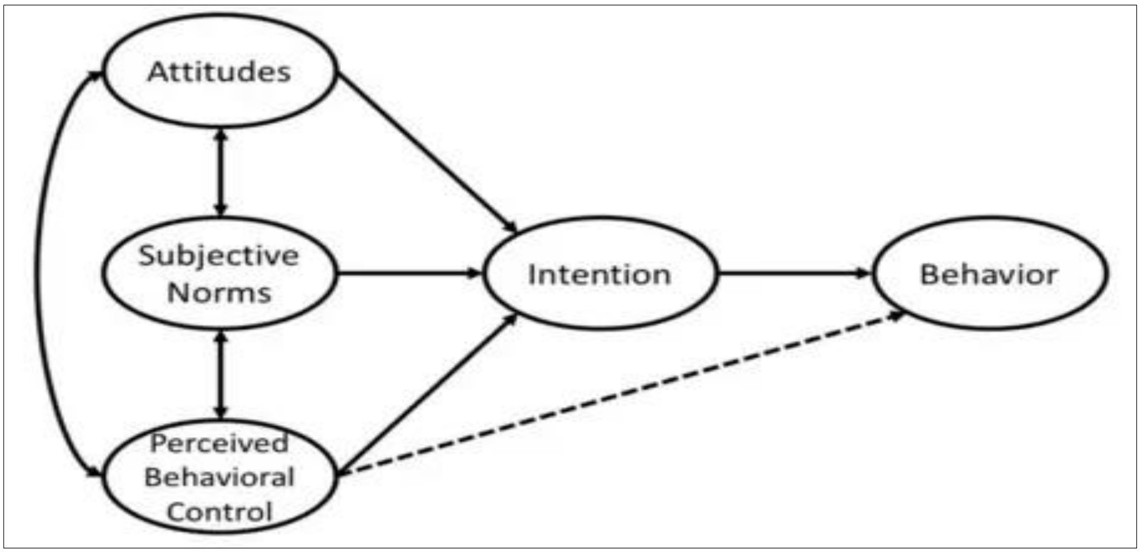

Figure 2.1: Behavioural beliefs perceived by social pressure) and control beliefs trigger perceived behavioural control

As noted in Figure 1 above, behavioural beliefs result in a favourable or unfavourable attitude toward a specific behaviour, normative beliefs result in subjective norms (perceived social pressure) and control beliefs trigger perceived behavioural control. Usually, the greater the favourable behaviour, subjective norm, and perceived control, the stronger the person's intention to display the behaviour in question.

The TPB psychological drivers are determined by background factors such as individual and organisational dispensation (Ajzen & Fishbein, 2007). Organisational safety behaviours are generally mandated, whereas personal safety behaviour factors are frequently voluntary. Primary organisational factors are management commitment and work pressure. Management commitment influences employee behaviour at work. For instance, the management can provide employees with PPE, which can motivate safe behaviour. Priya and Susweta (2015) argue that workers behave unsafely partly due to the work pressure imposed on them by their supervisors. Individual factors mainly include safety knowledge and health conditions closely associated with safety behaviour (Brogli, 2016). Bunniss and Kelly (2015) indicated that safety knowledge poses a considerable positive synthesised effect on safety behaviour.

Quarry mines and construction sites are equipped with human capital, an important and vital resource, and call for respiratory safety behaviour in a workplace environment. Therefore, applying the TPB helps to determine the level of workplace respiratory safety and understanding of changes in human behaviour. In this study, the behaviour of quarry and allied workers towards respirable dust was examined.

2.2.3 Trans-theoretical Model/Stages of Change Model (TTM/SOC)

James Prochaska and his colleagues developed the Trans-theoretical Model (TTM/SOC) of change. The TTM theorises that temporal behaviour integrated with processes and principles can change an individual’s behaviour (Prochaska et al., 1992). According to this theory, people are at different stages in acquiring a particular health behaviour (Prochaska, 2013). In the TTM/SOC, Prochaska et al. (1992) propose that individuals progress through six interlocking stages to engage in health behaviours. In the first stage, pre-contemplation is when people do not think seriously about changing their behaviours to attain better health. In this stage, individuals are either unaware or aware of their health problems and the need to alter their behaviour (DiClemente et al., 1994). During the contemplation stage, people know that a health problem exists and have earnestly begun thinking about behaviour change but have not yet committed themselves to action (Prochaska, 2013).

The third stage of the model is preparation, in which the individual is preparing to enact the health behaviour in question. The next stage is the action stage, when individuals make unambiguous changes in their behaviour, experiences, or environment to address health problems (DiClemente et al., 1994). The beginning of the maintenance stage is sometimes defined as 6 months following taking overt action to engage in the desired health behaviour. The termination stage involves continuing with a behaviour achieved over time (Prochaska et al., 1992). The six processes of change can be associated with a person’s progression from one phase to another.

Figure 2.2: Stages of behaviour change

As shown in the figure above on the stages of behaviour change, the first stage of this model is where an individual has no aim to change his/her behaviour and may not be aware of any need to change (pre-contemplation). In the second stage, an individual is well-informed but unsure about changing (contemplation). Thereafter, the individual considers moving forward towards changing (preparation), and then one will start being committed to the new behaviours (action) and upholding such behaviours (maintenance). Progression through the stages defined by the model is not necessarily linear, as relapses may occur, and individuals return to either the pre-contemplation or contemplation stages before finally succeeding in maintenance.

In this study, the TTM will be used to determine the respiratory health behaviour of quarry and allied workers concerning their knowledge, attitudes, and compliance with respirable dust legal provisions or standard ways. The TTM model is ideal for elucidating the study outcomes through education and explaining the respiratory protection remedies. Therefore, quarry and allied workers will be expected to change their attitudes towards respiratory protection through their individual or social behaviours. Thereafter, both the management and the quarry and allied workers will abide by the respiratory legal framework in their workplaces, whereby employers will apply necessary respiratory protective measures, while the quarry and allied workers will comply with the provided measures. However, there may be those who will go back to their past practices of not abiding by respiratory protection measures, which may be influenced by many things, such as economic downfall or failure to adopt new changes. The TTM can be applied to promote respiratory protection programmes to address adverse respiratory issues within quarry mines, construction sites and related dust-producing environments.

2.3 Protection of Quarry and Allied Workers from Respiratory Conditions and Infections

The current protection of quarry and allied workers from respiratory conditions and infections is presented using the hierarchical hazard control model. The hierarchy of controls ranks 5 levels of actions to reduce or remove hazards from the most to least effective. Based on this study, 3 levels of action controls for reducing respiratory hazards have been identified from the most to least effective as engineering controls, administration controls and use of PPE/C.

2.3.1 Engineering Controls

Engineering controls are physical modifications implemented in a work environment that aim to remove or minimise exposure to a hazard (National Institute for Occupational Safety and Health, 2019). Engineering controls prevent workers from encountering hazards or minimise potential exposure. According to Gürcanl, Baradan and Uzun (2015), respirable dust engineering controls are designed to remove or reduce the hazard at the source by suppressing, diluting, or diverting dust generated by mining, construction and associated activities. Examples of respirable dust engineering controls include proper ventilation systems, the use of water sprays, water mist (wetting agents), and control booths or environmental cabs to enclose equipment operators (National Institute for Occupational Safety and Health, 2021). Zhang et al. (2016) mention that engineering controls are the most effective means of controlling the amount of dust to which quarry and allied workers are exposed as they address dust at its source, thus ensuring adequate protection. You, Li, Li, and Xia (2019) argue that engineering controls provide more consistent and reliable protection than other interventions because the controls are not dependent on an individual’s performance, supervision, or intervention to function as intended. That is, they require minimal worker involvement and hence provide a long-term solution.

According to Gürcanl, Baradan, and Uzun (2015), respirable dust engineering dust controls in quarry mining and construction sites include water mists and sprays. This controls dust exposure in quarrying, mining, stone grinding, and construction. Occupational Safety and Health Administration (2016) tested engineering controls that included water sprays incorporated into drilling tools, with a simple garden hose used as a sheet of water wetting. Sheet water wetting as an engineering control provided the best exposure reductions, as water sprays incorporated into drilling and grinding tools did not always direct sufficient water where it was needed (Jacobsen, Schaumburg, Sigsgaard, & Schlünssen, 2021). Available engineering controls include water sprays for handheld saws and water sprays or dust capture for table saws. A water mist, sometimes with a detergent, is injected into the blowing air, which helps the dust particles coalesce and drop out (Kokkonen-et al., 2019). Too much water forms a bridge or collar between the drill steel and the side of the hole. These often have to be broken to remove the bit; too little water is ineffective (Meeker, Cooper, Lefkowitz, & Susi, 2009). Problems with this type of control include a reduction in the drilling rate and a lack of a reliable water supply. Water sprays, strategically placed close to the cutter head and forcing dust away from the miner and towards the face, also assist in reducing exposure (Rupani, 2023).

Water sprays moisten dust ejected from the drilling and can reduce respirable dust emissions by up to 96% (NIOSH, 2019; NIOSH, 2021). Subsequently, the absence of water sprays will raise 20 times the respirable dust concentration than the usual level concentration (NIOSH, 2021). An experiment using water spray showed that dust reduction was less effective each time additional spray nozzles were deactivated. A 10% decrease occurred when three of the 21 sprays were shut off. Decreased total water spray volume and gaps in the spray pattern (due to deactivated nozzles) were partially responsible for the decreased dust control (Vacek et al., 2019).

Although considered a supplementary or secondary measure to engineering controls, administrative controls can further reduce quarry and allied workers' exposure to respirable dust and other airborne contaminants.

2.3.2 Administrative Controls

Administrative controls are guidelines and protocols implemented in the workplace environment to reduce or minimise worker exposure to hazards (OSHA, 2016). Administrative controls refer to employer-dictated work practices and policies that reduce or prevent hazardous exposures. Hence, their effectiveness depends on the employer's commitment to acceptance and consistent use (Zhou, 2018). According to Zhou, Whyte, and Sacks (2014), administrative controls provide additional guidance and procedures, demonstrating the company's commitment to safety and enhancing the overall safety culture of the workplace. In protecting quarry and allied workers, administrative controls come from educational programmes and medical surveillance.

2.3.2.1 Educational /Training Programmes

Appropriate training is necessary to ensure that employees know about respiratory protection, cooperate, and actively participate in the respiratory protection programme (Zin & Ismail, 2015). Furthermore, training eliminates complacency in employers and employees concerning respirator use. It also ensures a reasonable number of recalls and performance for the respirator user (Draid, Bn-Elhaj, Ali, Schmid, & Gibbs, 2015). Kumar et al. (2014) recommend that training be provided more frequently to properly retain the knowledge necessary to use PPE (respirator). During training, employees interact with trained professionals who can provide instruction and understanding in using

PPEs correctly to overcome employee resistance to proper PPE usage (NIOSH, 2021). The OSHA believes that a lack of training tends to diminish employee attention to proper respirator use and may result in a long period of poor respirator practice before problems are identified and corrected. When employers require employees to use PPE, such as respirators, employees must be adequately trained in their use and care and be informed of the limitations (Alemu, Yitayew, Azazeh, & Kebede, 2020). Employers must implement employee training requirements because the use of PPEs may present a health hazard to employees who do not have adequate information to use and care for respirators properly and who do not understand the limitations of respirators (NOISH, 2021).

Educational and training programs on safety precautions and behaviours, especially proper use of PPE, have been shown to be effective methods to increase knowledge and prevent respiratory symptoms and diseases related to the quarry, construction, and allied exposures (Jacobsen, Schaumburg, Sigsgaard, & Schlünssen, 2021). Ye et al. (2013) discovered that educational training programmes on safety precautions and PPE use decreased lung diseases linked to dust exposure. One Australian study focusing on Wisconsin quarry workers found that PPE use significantly increased following a 6-month educational programme intervention (Ye et al., 2013). Education focusing on basic respiratory safety and proper PPE use on quarry and allied workers is essential to inform individuals of occupational-related lung disease risks and to change attitudes, knowledge, and behaviours (Cramer et al., 2016).

Knowledge of occupational health and safety and the use of N95 masks increased in the intervention group, whereas very few improvements or negative changes were observed in the control group. Dolinar (2018) provided education on lung health risks for Nigerian construction workers; 18.8% of study participants wore a respirator for 3 months post-intervention, which was improved from only 6.3% of individuals who wore a respirator all the time pre-intervention. Kearney et al. (2015) conducted interviews with construction workers in the Northeastern part of Nigeria. It was concluded that construction workers were aware of the occupational hazards and risks, as they showed concern for protecting their health and safety. Yarpuz-Bozdogan (2018) found that artisanal miners in Zimbabwe's knowledge surrounding the adverse effects of mining improved with education and training.

2.3.2.2 Medical Surveillance Measures

Health and safety law requires health surveillance to help protect them from health risks at work. Health surveillance in respiratory protection is an outline of repeated employee medical assessments and obtaining information such as history tracking, regular physical examinations, chest X-rays, and lung function tests (Almberg et al., 2020). According to Arstad and Aven (2017), medical surveillance provisions reduce quarry workers' mortality and morbidity from respirable dust exposure. Medical surveillance measures include medical examinations, which review an employee's medical and work history, and a physical examination. The medical and work history covers an employee's present and past work exposures, illnesses, and symptoms indicating respirable dust-related diseases and compromised lung function (Lancet, 2019).

According to NOISH (2019), mining and construction enterprises should provide a mandatory initial medical examination for each new employee. Mandatory initial examinations are conducted when workers are first hired in the mining and construction industry, providing an individual baseline of each employee's health status (Zin & Ismail, 2015). NIOSH (2019) mentions that initial examination assists in the early detection of respirable dust-related illnesses and conditions that may make the miner more susceptible to the toxic effects of respirable dust. The individual baseline would also be valuable in assessing any future health changes in each employee. Overall, the initial examination results would enable miners to respond (Lancet, 2019). Periodic examinations allow for comparisons with an employee's prior examination results, help detect respirable crystalline silica-related disease, including silicosis, and address the further progression of existing respiratory disease (Almberg, Friedman, Rose, Go, & Cohen, 2020).

An important element of an effective respiratory protection programme is the medical evaluation to determine whether an employee can use a given respirator (Zin & Ismail, 2015). Employees whose employers are required to wear respirators must also be medically evaluated to determine that they can tolerate the increased physiological load associated with some respirator use. Using respirators may present a health hazard to employees who are not medically able to wear them (OSHA, 2016). The physiological burden associated with respirator use includes the burden imposed by respirator weight and breathing resistance during regular operation and under conditions of filter, visual, and odour sensations. NOISH (2019) reiterates that factors to be considered include the duration and frequency of respirator use, the level of physical work effort, protective clothing use, and extreme temperature or high humidity. Specific medical conditions can compromise an employee's ability to tolerate the physiological burdens imposed by respirator use, thereby placing the employee at increased risk of illness, injury, and even death (Arstad & Aven, 2017). The medical conditions include a history of high blood pressure, heart attack, asthma, chronic bronchitis, and reduced pulmonary function caused by other factors such as smoking or prior exposure to respiratory hazards. (Kim et al., 2012).

2.3.3 Personal Protective Equipment/Clothing

Personal protective equipment (PPE) controls are the last line of defence in protecting workers from dust exposure when engineering and administrative controls are not feasible or do not provide adequate protection (Alemu, Yitayew, Azazeh, & Kebede, 2020). According to Ashley and O'Connor (2017), PPE provides direct protection to workers as a supplementary control. Respirators are effective personal protective equipment in protecting employees from exposure to respirable dust.

2.3.3.1 Type of PPE/C Provided

NOISH (2019) recommends the use of respirators as an interim measure when engineering and administrative controls are ineffective in maintaining worker exposure to respirable dust at or below the proposed Permissible Exposure Limit (PEL). Multiple respirators are available depending on which hazardous substance the quarry and allied workers are exposed to. Whenever respirators are used, the employees should be provided with NIOSH-approved atmosphere-supplying respirators or air-purifying respirators (Mrema et al., 2015). Atmosphere-supplying respirators provide clean air from a separate source (e.g., a self-contained air tank). In contrast, air-purifying respirators use filters, cartridges, or canisters to remove contaminants from the air (Lee et al., 2010). Common air-purifying respirators include elastomeric respirators, Filtering Facepiece Respirators (FFRs), and Tight-Fitting Powered Air Purifying Respirators (PAPRs). Elastomeric respirators, such as half-facepiece or full-facepiece tight-fitting respirators, are made of synthetic or natural rubber material and can be cleaned, disinfected, stored, and repeatedly reused (Jacobsen, Schaumburg, Sigsgaard, & Schlünssen, 2021).

Half-face piece respirators protect from smaller dust particles, and full-facepiece respirators provide eye and respiratory protection. The continued dust exposure by the quarry and allied workers emphasises the importance of FFRs in dusty environments (Vacek et al., 2019). The FFRs are designed to cover areas of the wearer’s face from the bridge of the nose to the chin. They are disposable respirators composed of a weave of electrostatically charged synthetic filter fibres and an elastic head strap (Zhang et al., 2016). Disposable N95 respirators protect against larger dust particles. PAPRs utilise a blower to move ambient air through an air-purifying filter that removes particulates and delivers clean air to the wearer (Rengasamy, Shaffer, Williams, & Smit, 2017). Respirators have different levels of protection and are used in various conditions. Individuals must understand which mask will protect them from exposure. Sapbamrer et al. (2021) found that surgical masks are the least protective, with a 25.7-61.5% filtration efficiency, and half-facepiece P100 respirators were the most protective, with a 96.5-98.9% filtration efficiency.

Respirators approved by NIOSH and suitable for their intended purpose must be provided by employers at no cost to mine and construction workers to effectively protect themselves from respirable dust (Jacobsen, Schaumburg, Sigsgaard, & Schlünssen, 2021). Situations in which respirators are relied upon to protect from these hazards include those that involve immediately life-threatening situations as well as routine operations where engineering controls and work practices are not able to provide sufficient protection from these hazards (Jiang & Luo, 2021). Evidence on current workplace exposure levels confirms that respirators are needed in many work situations to protect workers against serious work-related illnesses (Rengasamy, Shaffer, Williams, & Smit, 2017). The Agency for Toxic Substances and Diseases Registry (2019) mentions that without respirators in mining and construction environments, there is a greater chance that an employee will inhale potentially dangerous air contaminants. According to Jacobsen, Schaumburg, Sigsgaard, and Schlünssen (2021), without a respiratory protection programme, employees working under respirable dust exposure are presented with health risks as they are not provided with the expected level of protection, which increases the possibility of overexposure to a harmful air contaminant.

2.3.3.2 Provision and Experiences Associated with PPE/C Usage

The key factor in the usage of PPE is correctly selecting a Respiratory Protective Equipment (RPE) following a given pollutant(s) and its proper wearing, which is crucial in ensuring adequate protection (Ashley & O'Connor, 2017). The lack of knowledge and adequate training on the selection and/or use of RPE has led to many fatal injuries, such as asphyxiation, among workers (Alemu, Yitayew, Azazeh, & Kebede, 2020). Accordingly, it has been recommended that RPE should be used only in a systematic and documented manner, as detailed in the Respiratory Protection Program (RPP)

The 2020 respiratory safety survey that was carried out in Morgantown found that 35.7% of quarry and construction workers in developing countries wore a respirator in the last 12 months (Casey & Mazurek, 2020). Quarry workers were more likely to wear respirators than construction workers (39.1% and 32.5%), and charcoal workers were 3.5 times less likely to wear respiratory protection than any other category (Casey & Mazurek, 2020). In Yarpuz-Bozdogan's (2018) study, using PPE decreased the intermediate risk of respiratory injury by 44%, the maximum risk by 32%, and increased the chances of no risk of respiratory effects by 24%. In addition, a study conducted in Eugene found that the side effects of dust exposure decreased by 55% among quarry workers who wore proper PPE (Ye et al., 2013).

Dhatrak and Nandi (2019) in India discovered that compliance with respiratory protection guidelines in many industries is troublingly low, especially among workers in construction and mining. Yarpuz-Bozdogan (2018) in a study carried out in Cameroon, found out that some quarry workers chose not to wear PPE for multiple reasons, which include uncomfortable PPE, inconvenience, interference with work, and undesirable personal appearance and because of meteorological factors such as hot weather conditions. A more recent study by Coffman et al. (2021) that evaluated respirator use in the US identified several shortcomings in RPPs that could potentially be attributed either to employer unfamiliarity with regulatory requirements or to the possibility that employers are not allocating the necessary resources to implement such guidelines. Of the industries surveyed, 66% did not have a written program for deciding how respirators are used (Dhatrak & Nandi, 2019).

A study by Hicham et al. (2017) on participants' attitudes toward the use of respirators indicated only slightly positive attitudes toward respirator use, which could be due to issues with comfort and practicalities. Poor communication, personal comfort, vision, difficulties breathing, and fatigue have negatively influenced respirator use (Baig et al., 2010). The use of N95 by quarry workers or any other worker is hampered by relevant issues such as the difficulty in forming and maintaining an airtight seal that diminishes fit against the face (Bergman et al., 2015). Additionally, factors associated with the perception of discomfort while worn, such as heat caused by exhaled breath, tightness against the face, and the additional effort required to breathe through the filter media layers of an N95 filter, were also raised (Shaffer & Janssen, 2015). Discomfort is the most typical reason Guerin and Toland (2020) indicated for improper use of respirators, but this may encompass a variety of sensations and experiences, most commonly facial pressure, facial heat, facial pain, laboured movement of facial muscles, or skin itchiness. Psychologic manifestations of respirator wear, such as claustrophobia, may also be considered forms of discomfort, and improper usage of these devices is relatively common such that it may lead to discomfort (Almberg, Friedman, Rose, Go, & Cohen, 2020). Interference with occupational duties in the field of health care is a common problem as well.

According to Fukakusa, Rosenblat, Ribeiro, Kudla, and Tarlo (2011), non-compliance of co-workers, not having conveniently located respiratory protective devices, lack of safety training with respiratory protective devices, lack of fit testing availability and age stated as the non-usage of PPE. Wearing PPE is uncomfortable, and wearing PPE limits the wearer's mobility, the reason for the non-usage of PPE (Huck, 1996). According to Kearney et al. (2015), construction and quarry workers who choose to wear PPE regularly do so for the following reasons: to avoid injury (70%), family telling them to wear PPE (38%), ease of using PPE (36%), and low cost of equipment (22%). Better control of safety behaviours, such as wearing PPE, is critical for lowering the risk of mining and construction-related respiratory symptoms and diseases.

2.3.3.3 Respirator Fit Testing

Several studies support using respirators for lung protection while working with hazardous occupational inhalants. Hence, fit testing becomes necessary to ensure maximum respiratory protection (National Centre for Environmental Health, 2014). Respirator fit testing is performed to confirm the correct mask size without air leaks to provide individuals with maximum protection from hazardous inhalants (Dolinar, 2018). This means that before an employee is required to use any respirator facepiece, the employee must be fit-tested with the same make, model, style and size of respirator that will be used. Fit testing may be either qualitative or quantitative (OSHA, 2016). A qualitative or quantitative fit test should ensure that tight-fitting respirators properly fit with users' faces and that contaminants cannot leak into the respirator face piece (NOISH, 2021). Qualitative fit testing (QLFT) involves the introduction of a gas, vapour, or aerosol test agent into an area around the head of the respirator user. If the respirator user can detect the presence of the test agent through subjective means, such as odour, taste, or irritation, the respirator fit is inadequate (NOISH, 2021). In a quantitative respirator fit test (QNFT), the adequacy of respirator fit is assessed by measuring the amount of leakage into the respirator, either by generating a test aerosol as a test atmosphere, using ambient aerosol as the test agent or using controlled negative pressure to measure the volumetric leak rate (NOISH, 2021). Appropriate instrumentation is required to quantify respirator fit in QNFT.

In a health hazard evaluation (HHE) conducted by NIOSH at a medical centre, NIOSH found that workers using disposable respirators were not getting adequate protection because the respirators had not been fit-tested (NIOSH, 2019). Other HHEs conducted by NIOSH show that workers who used respirators without fit testing suffered adverse health effects from overexposure to airborne contaminants (NIOSH, 2021). OSHA concludes that poorly fitting facepieces expose workers to contaminants and that using an effective fit testing protocol is the best way of determining which respirator facepiece is most appropriate for each employee (OSHA, 2016). Proper fit testing is necessary to ensure that discomfort is minimised and that the respirator selected offers sufficient protection (Jiang & Luo, 2021).

2.3.3.4 Conditions Interfering with Respirator Use

The use of respirators is commonly affected by fit factors such as facial hair. If a tight seal is not maintained between the facepiece and the employee's face, contaminated air will be drawn into the facepiece and breathed by the employee (Rengasamy et al., 2017). However, a study by Geng and Saleh (2015) investigated the effect of facial hair on the performance of half-mask and full-facepiece respirators. Quantitative fit test results showed that facial hair can have a range of effects on respirator performance, depending on factors such as the degree to which the hair interferes with the sealing surface of the respirator, the physical characteristics of the hair, the type of respirator, and facial characteristics. In general, the presence of beards and wide sideburns had a detrimental effect on the performance of the respirators (Jacobsen et al., 2021). This means that individuals with excessive facial hair, including stubble and wide sideburns, that interfere with the seal cannot expect to obtain as high a degree of respirator performance as clean-shaven individuals. Consequently, the degree of interference depends on many factors (*e.g.*, the length, texture, and density of facial hair) and how those factors interfere with the respirator's sealing surface. Nguyen et al. (2021) add that tight-fitting facepieces are not to be worn by employees with any condition that interferes with the face-to-facepiece seal or with valve function. Such conditions may include the growth of the beard or sideburn.

Other fit-testing studies also show that non-bearded workers have significantly higher fit factors than bearded workers. Skretvedt and Loschiavo (2016) tested half-mask and full-facepiece respirators on 370 male employees who were fit-tested qualitatively and quantitatively; 67 had full beards. The bearded workers consistently failed qualitative fit testing. Bearded employees using half-masks had a median fit factor of 12, while clean-shaven employees had a median fit factor of 2950. For full facepiece respirators, bearded workers had a median fit factor of 30, and clean-shaven employees greater than 10,000 (NCEH, 2014).

Only one study found no significant difference in respirator performance for employees with or without beards. Fergin (2014) studied workplace protection factors, but not fit factors, for three different types of disposable respirators used by carbon setters during carbon setting and ore bucket filling operations. However, a study in Ghana, which involved 75 samples collected from 38 non-bearded and 22 bearded workers, compared ambient concentrations with "in-mask" concentrations. Beard types were classified as light, medium, heavy, fine, soft, coarse, and curly (Ahadzi, 2021).

2.3.4 Association between Employee Level of Respiratory Protection with Individual and Work-Related Factors

Several studies have shown that individual and work-related factors influence employees' respiratory protection levels.

2.3.4.1 Individual Factors

Research published across various occupations shows several individual factors as important determinants of the level of respiratory protection among quarry and allied workers. These factors include personal characteristics such as age, gender, work experience, level of education, knowledge (training) of respiratory protection hazards, and risk perceptions of respiratory protection (Z'gambo, 2015)

2.3.4.1.1 Relationship between educational attainment and PPE usage

Numerous ideas in the field of health behaviour research contend that the individual level of education plays a critical role in motivating people to adopt respiratory protection behaviours or refrain from protecting themselves from respiratory hazards (International Labour Organisation, 2013). According to various theories in health behaviour research, knowledge is a key component of motivation to engage in health-enhancing behaviour and or avoid unhealthy behaviour (Janz & Becker, 1984; DiClemente, Prochaska, Fairhurst, Velicer & Velasquez, 1994). Knowledge of consequences resulting from exposure to hazards has also been shown to be a predictor of respiratory protection. In a study conducted to assess awareness of safety and health practices and respiratory protective equipment use, the significant determinants for using PPE included the risk of exposure and knowledge of the consequences of the exposure (Nelson, 2013).

A study by Almberg et al. (2020) in North America found that the respondents' level of education significantly affected respiratory protection, particularly when comparing respondents with and without formal education. However, the difference between individuals with basic education and those with higher education was not statistically significant. Research findings by Jacobsen et al. (2021) in Norway showed that people who did not complete formal education also did not protect themselves from respiratory hazards as they shunned the proper PPEs at work. Of those with a primary education, 14 (43.8%) utilised personal protective equipment (PPEs) at work, compared to 18 (56.2%) who did not. A study conducted in Zambia that assessed respiratory protection among construction workers in Lusaka indicated that employees with no education had the least proportion reporting the use of PPE, training on respiratory protection and use of engineering controls compared to those with primary and secondary education (Z'gambo, 2015). However, in another study on occupational safety and health practices among quarry workers in Ghana, results indicated no association between the use of respiratory protection and respondents' educational level (Monney et al., 2014).

2.3.4.1.2 Relationship between age and use of PPEs

Age has been seen as playing a significant role in how quarry and allied workers use their PPE. In a study by Kumar, Gupta, Agarwal and Singh (2016) on respirator usage, age emerged as an important factor influencing risk perception. Older and more experienced workers reported being more likely to wear PPE than their younger counterparts. Older workers attributed this phenomenon to younger workers' lack of experience and feelings of invincibility. Younger workers suggested that they had not yet formed a habit of using PPE or did not realise its importance for specific tasks (Kumar, Gupta, Agarwal, & Singh, 2016).

Additionally, Z'gambo (2015) found that the proportion of construction workers using at least one type of PPE was lowest among the youngest participants, who were twenty-eight years and below. Contrary to the age variable and use of PPE, older employees reported lower use of PPE. This was attributed to older workers not having had a chance to be trained on the importance of PPE (Ahadzi, 2021). A study by Barnes, Goh, Leong and Hoy (2019) showed that older workers were found to dismiss the training and information received by younger workers who were new to the workplace, thereby undermining the information received by the workers.

2.3.4.1.3 Relationship between working experience and PPE usage

Working experience entails when an employee has worked or been exposed to the quarry mining or construction industry for a period of time. Employee working experience influences the use of PPE among quarry and allied workers. A study by Beth (2018) showed a relationship between years of experience and the use of PPEs, whereby a higher number of years of working experience showed improved utilisation of PPEs while working. That is, the majority (66.7%) of respondents with experience between 1 and 2 years did not always use PPEs while working, compared to 33.3% who used them. Similarly, 57.1% of respondents who had working experience of 3 to 4 years did not use appropriate PPEs while working, against 42.9% who cited they used (Long, Sun, & Neitzel, 2015). Furthermore, Z'gambo (2015) found that the proportion of construction workers reporting the use of PPE increased with an increase in work experience

In a different study by Rupani (2023), the scenario was observed to change for respondents who had work experience of 5 years or more. In the categories of 5 to 6 and 7 to 8 years of experience, equal proportions, 50%, and 50%, respectively, indicated the use or non-use of appropriate PPEs when working. Most respondents (80%) with experience of between 9 and 10 years always used appropriate PPEs when working. A similar picture was drawn from respondents with experience above 10 years, whereby 73.3% noted that they always used PPEs when working, while only 26.7% indicated they did not always use them. However, Monney et al. (2014) showed no statistically significant association between work experience and the use of personal protective equipment.

2.3.4.2 Work-Related Factors

2.3.4.2.1 Nature of Task/Job Category

Workers reported a lower rate of PPE use for tasks that took shorter periods to accomplish and did not involve repetitive work (Lombardi et al., 2009). The study also observed that construction workers mostly used respirators during the mixing phase of the mortar, but not in the building stage. This was attributed to the perceived seriousness of the expected consequences of exposure to cement dust as compared to mixed mortar (MacFarlane et al., 2007).

2.3.4.2.2 Worksite Risk Perception

Risk perception among individuals has also been shown to influence the use of PPE. Perception is defined as the result of a cognitive process whereby a person interprets information based on his or her understanding of that object (National Safety Council, 2014). Understanding workplace hazards and risks and how workers perceive the two is an important step toward developing programmes for raising awareness to make workplaces safer. Risk perception is the ability of an individual to discern a certain amount of risk. Theoretically, the inability to perceive risk by an individual may lead to higher risk-taking behaviour (NSC, 2014)

The protection motivation theory states that risk perception and use of personal protective equipment increase when workers have a reason for concern, oftentimes because of having suffered an occupational injury or illness (Mavhunga, 2018). In a study of the use of personal protective equipment among offshore workers, the workers who had experienced an accident or incident in the past felt less safe and were more aware of the risks than those who had not experienced an accident or incident (Nguyen et al., 2021). When workers are made aware of the hazards in their workplace, they are more inclined to use PPE to protect themselves from exposure to the hazards. Conversely, if workers are provided with PPE but are not told why or how to use PPE, likely, such PPE will not be utilised. Several studies have pointed out the importance of workers having knowledge of the hazards and risks posed by their work and how they can protect themselves from such hazards (Zhou et al., 2014). Tobin et al. (2016), in a study of factors influencing workers' use of respiratory protection in various industries, found that workers were more likely to understand the risks involved in the job when they were told at the beginning, when being hired, that PPE is required and they were trained on PPE use.

Similarly, a study in Nigeria by Sufiyan and Ogunleye (2013), assessing awareness of hazards and the role played by training in influencing the use of PPE, found that personal protective equipment was most likely donned when workers were more aware of the risks and more so in work sites where the risk was more apparent, for example higher noise levels and other more apparent risks like bright light and sparks from welding. In a study by the Health and Safety Executive (2014), an occupational research body in the UK, on respiratory protective equipment across four industries, brick making, construction, stonemasonry, and quarrying, the results indicated that despite workers being aware of the hazard, individual risk perception was often low. The study attributed this to many factors that affected risk perception, notably age. The study reported that older and more experienced workers did not consider the risk sufficient to require them to use PPE.

2.3.5 Challenges Faced in Protecting Quarry and Allied Workers from Respiratory Conditions and Infections

The following are challenges encountered in protecting quarry and allied workers from respiratory conditions and infections.

2.3.5.1 Weak Occupational Health Surveillance

Good data provides a foundation for designing an effective prevention strategy. Regular monitoring of the working environment and health surveillance of workers enable employers to prevent and report cases of occupational diseases (Eshiwani, 2014). However, more than half of all countries still do not collect sufficient statistics for occupational diseases. Available data primarily focuses on injuries and fatalities. Furthermore, only a few countries collect sex-disaggregated data (You et al., 2019). This complicates the identification of the specific types of occupational injuries and diseases affecting men and women and hinders the development of effective preventive measures for all. Official national statistics are based on reported data concerning occupational accidents and diseases (Gordis, 2013). Many countries have social security systems that include employment injury benefit schemes. However, their coverage is limited to workers in the formal economy. When available, effective coverage of employment injury benefits is sometimes insufficient due to inadequate recording and notification systems (ILO, 2013). Consequently, only a certain number of occupational incidents are reported, treated, and compensated. In most countries, only a fraction of the actual cases is reported, reflecting challenges in defining, recognising, and reporting them.

Meanwhile, rural workers, small and medium-sized enterprises (SMEs), and the informal economy, which represent much of the global workforce, face high risks because they tend to be outside the systems that prevent, report, and compensate for occupational illness (Gordis, 2013). This situation impedes adequate health surveillance, monitoring of the working environment, and the recording and notification of occupational diseases, all of which are required for effective implementation of preventive strategies. The increased movement of workers to different jobs with varying levels of exposure can make it challenging to determine an occupational origin. Additionally, some workers may contract diseases in jobs involving exposure to substances that have not yet been identified as hazardous (Ivensky, 2016). Diseases are diagnosed by medical doctors, and their prognosis in relation to work must be assessed to recognize their occupational origin. Diagnosing occupational diseases requires specific knowledge and experience that are often lacking in many developing countries. This limitation constrains data collection and national capacity in occupational health surveillance. In some countries, the responsibility for health and safety at work may be divided among labour, health ministries, and social security institutions, complicating data collection (ILO, 2013).

2.3.5.2 Lack of Prevention Priority Mandate

Many governments, employers' and workers' organizations are now placing greater emphasis on preventing occupational diseases. Even so, prevention is not receiving the priority warranted by the scale and severity of occupational diseases. Concerted efforts are needed at both the international and national levels to address the invisibility of occupational diseases (Mantovani & Bocos, 2017). Effective prevention of occupational diseases requires continuous improvement of national OSH systems, inspection and prevention programs, and compensation systems. Effective prevention necessitates collaboration at the national level between OSH institutions and employment compensation schemes within social security systems. Where preventive capacity is weak, especially in developing countries, the ILO has the tools and experience to help forge a response (Long, Sun, & Neitzel, 2015). According to Health and Safety Executive (HSE) construction statistics from 2019, construction is the sector with the highest number of health and safety-related accidents in the UK (National Centre for Environmental Health, 2014). This is due to inadequate equipment compliance, training, safety processes, and procedures.

2.3.5.3 Lack of Medical Care Data

A study in Nigeria found that data on the availability of medical care in the quarry industrial site and the use of protective devices by the quarry workers indicated that there was a total absence of medical care and a near absence of protective device usage by the workers (Nwibo et al., 2012). This accounts for the high prevalence of some of the respiratory problems reported in this study, which accounts for a decline in the respondents' mean FEV1 and FVC values. Only 13.7% of the dust-exposed workers had their mean FEV1 values in the green zone of 4.00–6.50 L (data not shown), indicating that the lung function of most respondents had been impaired (Nwibo et al., 2012).

2.3.5.4 Inability to Carry Out Risk Assessment

Assessment of risks enables managers to make informed safety plans to prevent accidents. Arstad & Aven (2017) reported that failure to evaluate accident risk can also cause respiratory infection protection to fail. Risk assessments are used to establish priorities so that the most dangerous situations are addressed first, and those least likely to occur and least likely to cause significant problems can be considered later (Ivensky, 2016). According to Zhang et al. (2016), risk identification, risk assessment, geologic influence mapping, geotechnical evaluation, risk analysis, risk mitigation, and monitoring are important elements of the risk management process that must be integrated into organisational safety plans. Regulations require employers to assess risks and hazards and implement control measures to prevent occupational injuries, accidents, and fatalities. Any identified hazards should be communicated to workers, and workers should be educated on how to control and eliminate the hazards (MoHSS, 2012). However, as reported in the Ministry of Labour and Social Welfare 2012/2013 annual report, risk assessment is not being conducted in some sectors of Namibia, as some companies are not developing safety policies, nominating safety committees or representatives to assist in the establishment and implementation of OHS (Brockmeyer, 2016).

2.3.5.5 No Legal Framework

Kumar, Gupta, Agarwal, and Singh (2016) acknowledge that mining and construction industry workers are unorganised and are exposed to occupational hazards with very little legal protection provided in their relevant governing legal requirements. According to Geng & Saleh (2015), a lack of legal frameworks in government policy and safety regulations in occupational safety and health in mining and quarrying can lead to accidents and incidents in the workplace. Sanmiquel et al. (2015) agreed that despite new laws being introduced to enhance occupational safety, accidents of different natures still occur, including fatal accidents. In common-law jurisdictions, companies have a common-law duty to take care of the safety of workers. Lack of safety regulations and enforcement, education and training, functional infrastructure, and equipment may lead to increased injury rates (Long et al., 2015).

2.3.5.6 Lack of Skilled Labour

Traditionally, mining and construction industry workers come from a rural background and are exposed only to agricultural work. During the break from work on their land, they take up work at the construction sites. They arrive at the construction sites with no prior skill in working as a tradesman in the carpentry, steel fixing, bricklaying, tile fixing, and painting trades (Geng & Saleh, 2015). Therefore, the big challenge within the sector is the concerns around health and safety, and the lack of properly trained employees.

2.4 Knowledge, Attitudes, and Practices of Quarry and Allied Workers on Occupational respiratory protection

The triad of knowledge, attitude, and practice in combination governs all aspects of life in human societies, and all three pillars together make up the dynamic system of life itself. In this context, the ensuing discussion builds up a thesis that focuses on the three pillars and their relevance to health services and medical care.

2.4.1 Employee Knowledge Level on Respiratory Protection

Knowledge is defined as information obtained via experience or learning (Stuart & Acheterberg, 2014). Cherry (2021) describes knowledge as the ability to learn, remember, and apply information reinforced by comprehension, experience, judgment, and skill. Health knowledge refers to facts, information, and abilities based on education or experience and conceptual or functional comprehension of a subject connected to health care. Nilsen (2015) divides the concept of health knowledge further into declarative health knowledge (credible knowledge linked to health issues such as identifying respiratory condition symptoms), procedural health knowledge (concerned with the application of fact-based knowledge which involves the use of (respiratory) occupational protective measures from work-related adverse conditions) and judgemental knowledge (the capacity to assess based on verifiable knowledge needed to deal with new situations) (Meeker et al., 2009). Having declarative, procedural, and judgmental knowledge relates to understanding given tasks, the context of what is required, and problem-solving techniques (Krathwohl, 2002). In this study, knowledge relates to quarry and allied workers' reception of respiratory protection information, which becomes grounded and begins to be applied and utilised.

Knowledge plays a mediating role in influencing the respiratory protection of employees from unsafe behaviour (Tuktur, 2017). In addition, Arstad and Aven (2017), a study in the United Kingdom, mentions that employees' knowledge of respiratory protection involves wearing masks, limiting dust exposure periods, and complying with respiratory guidelines. Thus, workers need to be educated on the proper usage of masks, which may prevent the worsening of pulmonary function due to dust exposure. Education is a precursor for knowledge that solidifies physical and intellectual abilities, fosters the growth of moral attributes, and demonstrates appropriate behaviour and manners (Ashley & O'Connor, 2017). The knowledge of quarry and allied workers on respiratory protection is premised on their awareness of the different types of strategies or methods used in restricting dust exposure to them. The employee knowledge level has been assessed by other scholars, and these are discussed below.

Nigerian construction workers were aware of the respiratory risks associated with their working environment; however, they did not apply workplace safety precautions such as wearing masks and respirators (Aloh, 2014). Dust masks helped control dust, according to Nigerian stone crushers, who saw it as a significant concern and the cause of their poor health. Similarly, Ghanaian gold miners acknowledge the main respiratory protection remedies following dust exposure as the leading cause of respiratory symptoms (Ahadzi, 2021). According to Mavhunga (2018), a study done in South Africa, most respondents knew that breathing dust might cause respiratory problems. Their prior job experiences in various coal dust settings may have provided them with this information. Most of the exposed individuals were also aware that breathing difficulties may emerge from prolonged or frequent exposure to coal dust and knew how to protect themselves from dust exposure (Mavhunga, 2018). Additionally, in a study by Ndlovu et al. (2019) in South Africa, most respondents were aware of dust suppression techniques to prevent exposure to quarry dust. Formative research by Geng and Saleh (2015) in China to determine mine workers' knowledge and attitudes toward respirable silica dust exposure revealed that mine workers were knowledgeable about activities that may expose them to respirable silica dust. Hence, bearing such information, the mine workers were aware of how to protect themselves from respiratory conditions associated with dust exposure.

On the other hand, a study in Tanzania by Mrema et al. (2015) found that most participants did not know of respirable dust concentration levels, as many were unsure or did not know how to protect themselves. The lack of knowledge could be attributed to the employer's failure to provide adequate information about allowable dust exposure limits and the available methods to protect employees from dust exposure. However, the same study by Mrema et al. (2015) showed that a minority of respondents knew how to protect themselves from occupational respiratory conditions attributable to respirable dust exposure. The few respondents were aware of the health issues induced by dust exposure. The health consequences that the respondents could be going through due to working in such conditions might be linked to their knowledge. A survey by Jiang and Luo (2021) in China on mine workers revealed no discernible correlation between exposure and understanding of the risks and hazards associated with respirable dust. The findings indicate that some workers were unaware of the potential risks and hazards of breathing in dust. Therefore, they did not know how to protect themselves from respirable dust. Hicham et al. (2017) reported that workers are unaware of the severity of the risks and dangers associated with their jobs and tend to take fewer preventive measures when performing their jobs. Similarly, Reiprich et al. (2016) asserted that if workers are not aware of the harmful effects of dust, they are unlikely to take precautions and are less inclined to protect themselves.

2.4.2 Employees' Attitudes to Respiratory Protection

DeJoy (1992) defines attitude as the mental and neutral state of readiness through experience and exerting an active or directive influence upon the individual’s reaction. Cramer et al. (2016) describe attitudes as acquired tendencies to judge situations or circumstances in a particular manner. Such judgments or assessments are frequently regarded as favourable or negative, favourable or unfavourable to a notion, object, or circumstance, but they can also be unclear at times. Premised in all the different definitions, attitudes are inclinations to react in a certain way to specific situations, to see and interpret events according to certain predispositions, or to organise opinions into coherent and interrelated structures. In this study, attitudes sum up a set of emotions, beliefs, and behaviours of quarry and allied workers towards respiratory protection, which can be expressed as positive or negative, favourable or unfavourable, depending on the workers' perspective (Leandre et al., 2006).

Employee attitudes toward respiratory protection are a psychological tendency of employees based on evaluative assessments of changes, both positive and negative assessments (Vacek et al., 2019). Positive employee attitudes toward respiratory protection can be shown by the willingness to adopt good work behaviour that promotes respiratory protection programs, while negative attitudes toward respiratory protection change can be seen in their resistance to and cynicism about respiratory protection (Mantovani & Bocos, 2017). Employees with a positive attitude can be relied on, while employees with a negative attitude will hinder the respiratory protection programme within the organisation (Singh & Gupta, 2016).

Positive attitudes among employees are linked to a higher likelihood of exercising caution while handling risks or illnesses (Vacek et al., 2019). Furthermore, it is believed that attitudes shift due to employees learning about potential risks at work and having the chance to be sensitive to dust-prone work situations. Workers' exposure to respirable dust is favourably reduced when the employees have positive attitudes toward respiratory protection programs. (Antao & Pinheiro, 2015). As a result, workers always wear personal protective equipment, such as respirators (Mantovani & Bocos, 2017). Individuals evaluate the results and predict their behaviour in each scenario. Therefore, someone who believes that engaging in a particular behaviour will have favourable results, whereas someone who feels that engaging in a specific behaviour would have unfavourable results, will have a negative attitude toward the behaviour (Vacek et al., 2019). This strategy is based on the idea that a person's attitude significantly impacts their work decisions.

A safety attitude study conducted in the Chinese coal mining industry revealed an overall improvement in the safety attitudes among coal miners (Lancet, 2019). This implies that the underground miners were more knowledgeable of the risks related to respirable dust exposure than the surface miners. They had more positive attitudes toward wearing PPE than surface miners, their work behaviour and practices toward exposure to respirable dust were better than those of the surface miners, and they were more compliant with safety standards than the surface miners (Lancet, 2019). Workers in Malaysian quarry mining had negative attitudes towards respiratory protection as they perceived that respiratory health and safety regulations made their work challenging and would prevent them from making the jobs easier (Aziz & Osman, 2019). Quarry miners in Turkey had negative attitudes regarding occupational safety issues as they did not wear respiratory protective equipment, thus putting themselves in danger (Gürcanl, Baradan, & Uzun, 2015).

2.4.3 Employees' Practices on Respiratory Protection

Practice is any customary action or proceeding regarded as an individual’s habit (Funk & Wagnalls, 2013). It implies that someone does something frequently as a product of knowledge. Igbokwe et al. (2015) defined practice as the actual performance or application of knowledge. According to Burton (2010), practice is the application of rules and knowledge that leads to action. Good practice is an art that is linked to the progress of knowledge and technology and is executed ethically. Two types of safety practices prevalent in work organisations have been described by Reiprich et al. (2016) as individual and organisational. Individual safety practices include awareness of work behaviours, attitudes, and habits relevant to the adverse effects of chemicals and objects used in the workplace, both in manufacturing and the physical setting. Organisational safety practices are steps taken by businesses to reduce risks at the workplace, such as training workers and providing up-to-date safety equipment and gadgets (Burton, 2010).

An integral part of safety practices in the building construction site is using personal protective equipment (PPE) such as face masks, face shields, goggles, overalls, and respirators. Safety practices are key to minimising workplace injuries and accidents. Work behaviour contributes to accidents in the workplace. Therefore, the presence of good safety behavioural practices results in workers complying with safety rules (Ivensky, 2016). Applying safety practices and measures through PPE by quarry workers will guarantee optimal safety for them. Optimal safety will engender sustainable development for the workers, employers, and the nation.

2.4.4 Association of Workers' Knowledge, Attitudes and Practices

According to NOISH (2019), knowledge, attitudes, and practices are a complete cycle; if one is not there, the cycle is incomplete. The trinity of knowledge, attitude, and practice (KAP) is inextricably linked and directly proportional. You et al. (2019) discovered that practices significantly correlated with their attitudes and knowledge. Knowledge is vital for instilling preventative ideas, cultivating positive attitudes, and encouraging best practices. According to Bandura (1997), a behaviour's motivation is tied to an attitude. A strong, positive linear connection between knowledge and attitudes, knowledge and practices, attitudes and practices, and knowledge and practices was reported (Sifanu et al., 2023).

Knowledge is crucial to fostering favourable attitudes that will encourage appropriate behaviour at work and lower exposure to respirable dust (Keil et al., 2018). Attitudes to lower workers' exposure to respirable dust positively correlate with knowledge of the associated risks and hazards. The report of Reiprich et al. (2016) indicates that attitudes to lessen the impacts of respirable dust on miners did not positively moderate information, suggesting that although workers are aware, their attitudes may not have an impact on their exposure to respirable dust. Long, Sun, and Neitzel (2015) observed that workers had positive attitudes toward occupational exposure. According to Tobin et al. (2016), for employees to participate in safe practices, they must exhibit specific behaviour. A study by Kumar et al. (2014) among study groups in India, aimed at empirically establishing the relationship between knowledge, attitudes, and work behavioural practices with safety standards for respirable dust exposure at mining sites, this study's findings revealed no direct significant relationship between knowledge of the risks and dangers of respirable dust, the attitudes of workers toward respirable dust, and exposure to respirable dust. The concept of being knowledgeable about potential occupational health and safety hazards in a workplace, as stated by Aluko (2016), is cardinal to having a positive attitude that may help workers portray a particular attitude. According to Nguyeni (2013) in a study conducted in Nigeria, a hazard or disease can be controlled if workers are knowledgeable about the risks and dangers of a particular hazard. To this effect, Takemura (2012) studied factory workers' occupational dust exposure. The study concluded that interventions for educating the workers helped with the prevention of respiratory diseases among the workers.

An observation from a study by Isara et al. (2016) in Nigeria found that work behavioural practices and compliance with safety standards were moderators between attitudes to the risks and dangers of respirable dust exposure and reduced susceptibility to respirable dust. Therefore, knowing the risks and dangers of respirable dust exposure is not enough to reduce exposure among workers. However, positive attitudes toward promoting good work behavioural practices reduce worker exposure to respirable dust because the knowledge of ownership is not good enough to influence exposure (Barnes et al., 2019). Beth (2018) in Zambia found no significant relationships between workplace working behavioural practices and compliance attitudes toward employee respiratory protection among workers exposed to respiratory dust. This implies that workers know the health risks associated with respirable dust exposure through awareness programs at the mine. However, there is a need to continuously monitor the work behaviour of miners concerning compliance with standards such as the routine wearing of PPE during operations.

Mantovani and Bocos (2017) in London discovered that most mine workers were aware of the health-protective measures to take when exposed to respirable silica dust to ensure they wore their respirators even when unnecessary. Additionally, Aloh's (2014) study in China revealed that mine workers' risky behaviour was partly propagated by their safety awareness. This finding implies that mining site management needs to keep up awareness campaigns for miners to incorporate the risks and hazards of respirable dust exposure into their good behaviour and practices. Whereas a study in Edo state found that there is a significant relationship between the education level of building construction workers and their use of safety practices (PPE) (Itohan & Anavberokhai, 2021). This finding is in line with that of Babatunde et al. (2013) in Nigeria, who conducted a study in Southwest Nigeria and reported that workers with higher levels of education appeared to use more protective devices. The study revealed that respondents knew about the health hazards of coal dust. Applying the rational model would assume that good knowledge among respondents would equally mean a positive behavioural choice, such as using respiratory protective equipment.

2.4.5 Factors Influencing Employee Knowledge

Employees' knowledge may be influenced by their education level. In Nigeria, for example, Ediagbonya et al. (2016) found that education was associated with PPE use, where the proportion of PPE use was higher among those with primary and secondary education compared to workers with no education. However, these results differ from findings from a study carried out among study population in country where Coffman et al. (2021) found that almost similar proportions were registered by respondents who had attained secondary education, whereby 21 (51.2%) protected themselves from respiratory hazards mainly using appropriate PPEs when at work and 20 (48.8%) while respondents who had primary education did not.

Regarding marital status, Dhatrak and Nandi (2019) in India recorded that single construction workers in India were more knowledgeable about occupational respiratory protection than married workers. On the other hand, Arrandale et al. (2017) discovered that married individuals had good knowledge and were noted to have an impact on a positive attitude toward safe working, which involved wearing masks and respirators. Those who have a positive attitude display safe practices. The most likely explanation is that marriage entails more outstanding obligations, which may make stable employment more valuable and important. In the same vein, Coffman et al. (2021) conducted a study on Northern California. They found that single workers were more susceptible to respiratory conditions than married workers, as they had less respiratory knowledge than married miners.

The training dramatically influences employee knowledge of occupational health and safety. According to NOISH (2019), training programmes strengthen employee skills and enhance knowledge and attitude. Kumar et al. (2016) discovered that trained workers concerning specific tasks and respiratory protection were primarily responsible for their occupational well-being. The mandatory respiratory training programmes for employees susceptible to respirable dust exposure assist in deterring respiratory symptoms and conditions among the workers (Dhatrak & Nandi, 2019). Most developed countries have undergone respiratory protection training to safeguard their workers from respiratory conditions.

2.4.6 Factors Influencing Employee Attitudes

A binary analysis by Long, Sun, and Neitzel (2015) revealed no correlation between workers' attitudes toward coal dust exposure and work experience. Therefore, the attitudes were similar among respondents with different lengths of work. This may be due to parallel trends of coal dust concentration levels found at the coal-fired power station. Consequently, all workers were fearful of developing respiratory problems. In a study by Zin and Ismail (2015) in Indonesia, construction workers 30 years old and older had positive attitudes, significantly associated with good knowledge.

As Nguyen et al. (2021) suggested, older workers have higher job satisfaction and a better view of safety. Thus, older workers are the most compliant with safety protocols and have the lowest risk of being involved in safety malpractices. In addition, as you get older, you gain more work experience. In Ebonyi State of Nigeria, Aloh (2014) found a substantial relationship between employee attitudes and respiratory protection among married and single construction workers. Kumar et al. (2014) submit that single employees in their work environment have negative attitudes toward respiratory protection. This finding suggests that married employees have more positive attitudes toward respiratory protection than single employees.

Osman et al. (2019) reported poor utilisation of PPE by workers in Northeastern Malaysia, which supports the findings of this study. These workers are fatigued by using PPE or feel that if nothing had happened to them for all these years, nothing would probably happen to them now or later. Similarly, the findings of this study are in line with earlier findings of Arrandale et al. (2017), who reported that when workers have positive attitudes toward their protection, they take more precautionary measures in performing their jobs.

2.4.7 Factors influencing employee practices

The topic of educational level, work experience, and marital status is critical in predicting an employee's respiratory protection practice. Mital and Ghahramani (2011) studied the occupational respiratory profiles of artisanal miners in Kenya and found that novice workers had more risky practices in their work than seasoned employees. There is a significant relationship between the years of experience and safety practices (PPE) among building construction workers in the Oredo local government area of Edo State (Isara et al., 2016).

This finding indicates that building construction workers who have spent more years on the job pay less attention and apply Laissez-Faire behaviour to the use of safety practices (PPE). This finding supports the idea that the more years workers stay on the job, the less they practice safety practices (use of PPE). The effect of personal variables on respiratory protection among British workers was analysed by Donald and Young (2012), who found that inexperienced staff had more unsafe practices than their experienced counterparts. Keil, Richardson, Westreich, and Steenland (2018) concluded that most respiratory conditions in employees occur due to novice workers.

A study in Nigeria by Vojakavic and Gordon (2010) reported that single employees took more precautionary practices than their married counterparts. However, Bråtveit et al. (2014) did not agree with single employees taking more precautionary measures than married workers. No significant weaknesses in the protection of married and single employees against workplace hazards were noted (Keil, Richardson, Westreich, & Steenland, 2018). On the contrary, Sifanu et al. (2023) found no substantial difference in the usage of protective practices by married and single employees concerning their occupational hazards.

2.6 Chapter Summary

This chapter reviewed relevant literature aligned with developing a framework for protecting quarry and allied workers from occupational respiratory infections. It began with an introduction to the theoretical and philosophical foundations of the study, emphasizing the pragmatic philosophy that guides this research. The chapter explored various paradigms, including ontology, epistemology, and axiology, to provide a philosophical basis for the study.

The chapter reviewed critical theoretical frameworks such as the Health Belief Model, the Theory of Planned Behaviour, and the Transtheoretical Model/Stages of Change Model, offering unique insights into understanding and influencing respiratory protection practices. The discussion also includes evaluating engineering controls, administrative controls, and the role of personal protective equipment (PPE) as hierarchical methods for safeguarding workers against respiratory hazards.

The knowledge, attitudes, and practices (KAP) of quarry and allied workers were explored, highlighting the factors influencing these dimensions and their interconnectedness in promoting respiratory protection. The literature also pinpointed challenges such as weak occupational health surveillance, lack of medical care data, and lack of a comprehensive legal framework.

The next chapter focuses on the study's methodology, detailing the research design, study setting, population, sampling procedures, data collection and analysis methods, and ethical considerations that underpin this research.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter outlines the research methodology adopted in the development of a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. A description of the research design, approach, and population under study, the sample size used, and the specific sampling techniques applied in selecting the sample are given. Additionally, data collection procedures and the approach to data analysis, together with a discourse on ethics, validity, and reliability, are discussed in this chapter. The study methodology is presented as aligned with the objectives.

3.2 Research Design

The research design refers to the overall strategy or plan integrating the different components of the study coherently and logically, thereby ensuring that the research problem is effectively addressed (Creswell & Creswell, 2022). It also bears the blueprint for the collection, measurement, and analysis of data. The study adopted the following study designs.

3.1.1 Descriptive Design

Objectives 1, 2, and 4 employed a descriptive research design. According to (Creswell, Vicki, and Plano, 2020), the suitability of a descriptive design is premised on the fact that it will provide insights into understanding the participants' underlying opinions and motivations on the protection of quarry and allied workers from respiratory infections. Additionally, the flexibility of the descriptive research design addressed the research questions of all types, such as what, why, and how, for both qualitative and quantitative data.

3.1.2 Exploratory Design

Part of Objective 2 employed an exploratory research design, in which Flick (2022) mentions that exploratory research investigates a problem that is not clearly defined, has been under-investigated, or is otherwise poorly understood. In this study, an explorative design was used to explore the quarry and allied workers' KPAs aligned to respiratory protection based on the managerial staff's point of view. In this instance, the nature of the problem (lack of respiratory protection) was elicited without quantifying it.

3.1.3 Experimental Design

Objective 3 employed an experimental design, which is a scientific method in which one or more independent variables are altered and applied to one or more dependent variables to determine their cause-effect association (Dawson, 2022). A laboratory experiment was conducted under highly controlled conditions, examining the filtration efficiency of the different types of masks or filters used by quarry and allied workers. The precise control of all external and internal factors or extraneous and independent variables allowed a cause-and-effect relationship to be established (Creswell, 2022). Employing the laboratory experiment used a standardised procedure, which enabled the study to be replicated, thereby ensuring credibility (SAGE Encyclopaedia, 2021).

3.2 Mixed Method Research Approach

This study utilised a mixed methodological approach to effectively test the research questions and address the research objectives. Thus, the quantitative and qualitative data collection and analysis stages were done together. A quantitative approach is more appropriate to determine the extent of the problem, issue, or phenomenon by quantifying the variability (Williams, Wiggins, & Vogt, 2022). In contrast, a qualitative approach is more appropriate to explore the nature of the problem, issue, or phenomenon without quantifying it.

Using the quantitative approach, the research sought to describe the observed situation of current practices in the protection of quarry and allied workers from respiratory infections, and the knowledge, attitudes, and practices of quarry and allied workers aligned to respiratory protection. The quantitative approach patterned and quantified the level of employee respiratory protection and the level of KAP towards respiratory protection. Quantitatively, the relationships between employee respiratory protection and work-related and individual factors were established (Dawson, 2022).

On the other hand, the qualitative approach was used to manage companies from which the quarry and allied workers were sampled. In-depth interviews with the management allowed the researcher to gain access to the perspectives on compliance levels and current practices in the working environment of quarry and allied workers (Neuman, 2021). The qualitative approach assisted in gaining an in-depth understanding and creating a more comprehensive insight into the phenomenon (Kumar, 2021). Using both quantitative and qualitative approaches provided a more comprehensive answer to the research problem by combining the strengths of both methodologies, gaining deeper insights. This approach allows for the exploration of diverse perspectives, enabling the collection of rich, contextual data alongside statistical analysis.

3.2.2 Study Site

The study was conducted in 3 regions, namely, Kunene, Erongo, and Otjozondjupa, as shown in Figure 3.1 below.

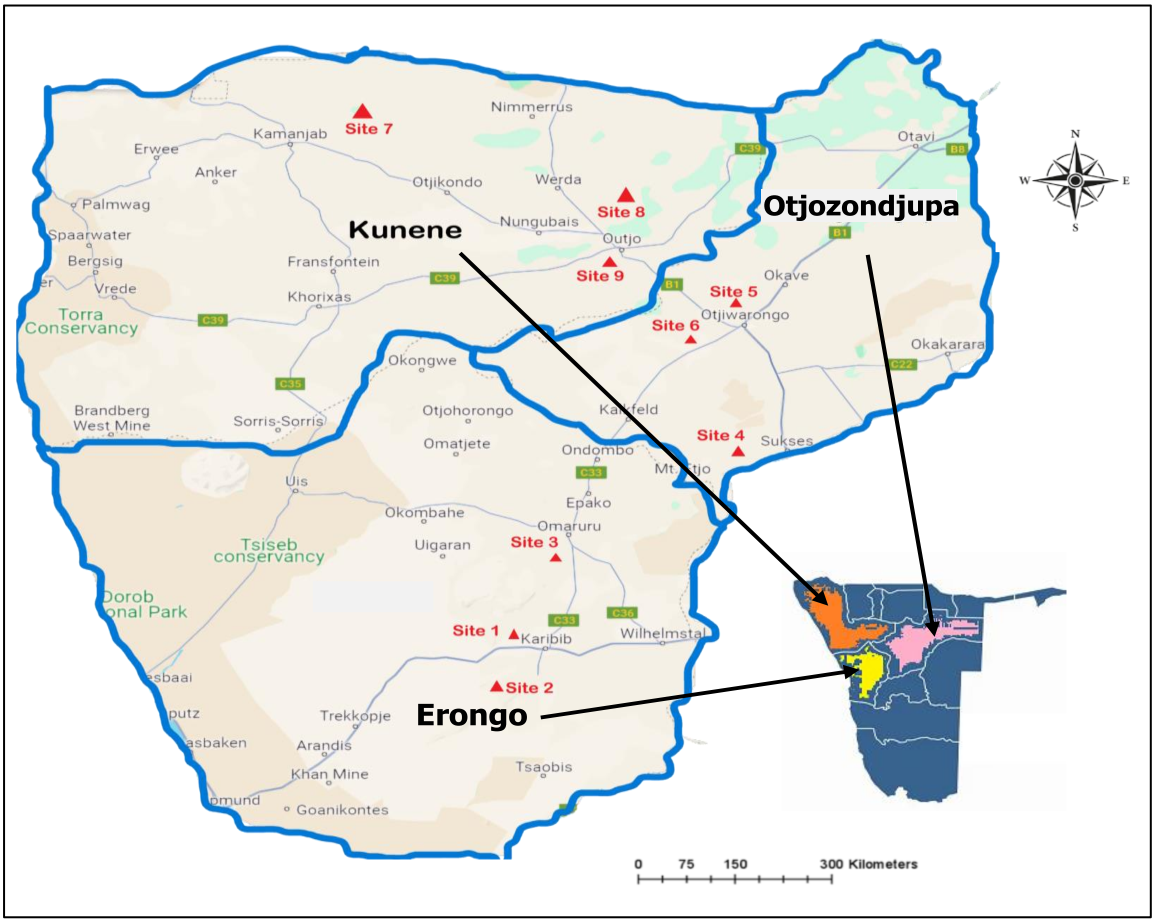

Figure 3.1 Map of Namibia, showing the three study sites

The area under study comprises of Namibian regions of Erongo with a population of 240,206, Otjozondjupa Region 220 811 and Kunene Region 120,762 (Namibia Statistic Agency, 2024). Erongo topography is extremely rough and rugged, comprising a mixture of mountain ranges, hills, sparse savannah plains, and wooded river valleys. Otjozondjupa is characterised by the Central plateau, fringe plains, mountain ranges, and massive bright red sandstone cliffs. Most parts of Kunene are rural, remote, and mountainous, without easy road access, with the landscape is divided into the interior highlands. The Erongo Region is the principal home of Namibia's fishing industry, a popular beach resort with its link to the coast of Namibia, and it has well-developed infrastructure (NSA, 2024). Cattle farming is a major source of livelihoods in the Otjozondjupa Region, with a rural landscape of underdeveloped infrastructure.

The study sites (all three 3 regions) resemble semi-arid conditions characterised by low rainfall, vegetation is generally sparse, with few trees and a thin covering of grass. Plant cover varies in relation to rainfall, and so the eastern parts of Erongo and Kunene have more trees and grass. Livestock farming (cattle, goats, and sheep) is a major agricultural activity because the landscape is unsuitable for crop farming due to its aridity and poor soils (NSA, 2024). However, livestock farming even gets increasingly precarious due to recurrent, protracted droughts. Various mining operations (marble industry) occur within all three 3 regions on both smaller and larger scales, with large organisations in the mining and construction industries (NSA, 2024). Small-scale mining for semi-precious stones, the sale of handicrafts, and employment at tourism facilities and heritage sites also contribute to livelihoods.

3.2.3 Study Population

This study population comprised the management of the selected mining organisations, quarry workers, and allied workers from three (3) regions in Namibia, namely the Erongo, Otjozondjupa, and Kunene regions. The regions were selected because they record a higher number of quarry activities, corresponding to a high prevalence of occupational respiratory conditions. Given that the selected three regions house most quarry mines and allied workers, their selection in the study enables the generalisability of findings across Namibia. Table 3.1 below shows the number of study participants.

Table 3.2: Categories of the study participants

Categories of Participants	Number
Quarry mine workers	367
Charcoal workers	287
Open-pit workers	102
Construction workers	356
Total	**1112**

3.2.3.1 Inclusion criteria

The following inclusion criteria were adopted

- Subjects working in quarry mines, charcoal production, and construction companies' production processes.
- Employees aged 18 years and above.
- Employee with at least one year of working experience in quarry mines and allied industries.

3.2.3.1 Exclusion criteria

The following exclusion criteria were adopted.

- Subjects working outside quarry mines and allied industries.
- Employees aged below 18 years.
- Employee with less than one year of working experience in quarry mines and allied industries.

3.2.4 Sample Size and Sampling

The sample size was obtained as follows:

3.2.4.1 Sampling Size of Quarry and Allied Workers

Determination of the sample size involves choosing the number of units or items to be used in the study. This study's quantitative sample size was determined using Taro Yamane's formula. Taro Yamane's formula is denoted by $n=N/(1+Ne^2)$, where n is the size of the sample, N is the target population, and e = is the percentage level of significance or the margin of error (Leung, 2020). Substituting N with 1112 (the target population extracted from the total number of quarry and allied workers as indicated in Table 1) at a 95% confidence level and 5% significance level. By this, an n value of 294 was obtained. However, to cater for possible spoiled or irrecoverable questionnaires, the sample size was revised to 320.

The quantitative approach used the multi-stage sampling technique, which involved using more than two stages of sampling based on the tiered structure of clusters in a given population (Kumar, 2021). In multistage sampling, a diverse cluster was selected at each stage, with the clusters nested within each other at sequential stages. Firstly, three regions, namely Erongo, Otjozondjupa, and Kunene, were selected based on the number of quarry and allied workers in each region. This was followed by the town tier selection; 2 towns were selected from each region. From each town, quarry mines, charcoal processing plants, and construction companies were chosen, and employees were stratified according to their job categories. Figure 3.2 shows the multistage sampling process. Finally, a simple random technique was adopted using the proportional allocation method for each job category (builders, excavator operators, sorters, drilling operators).

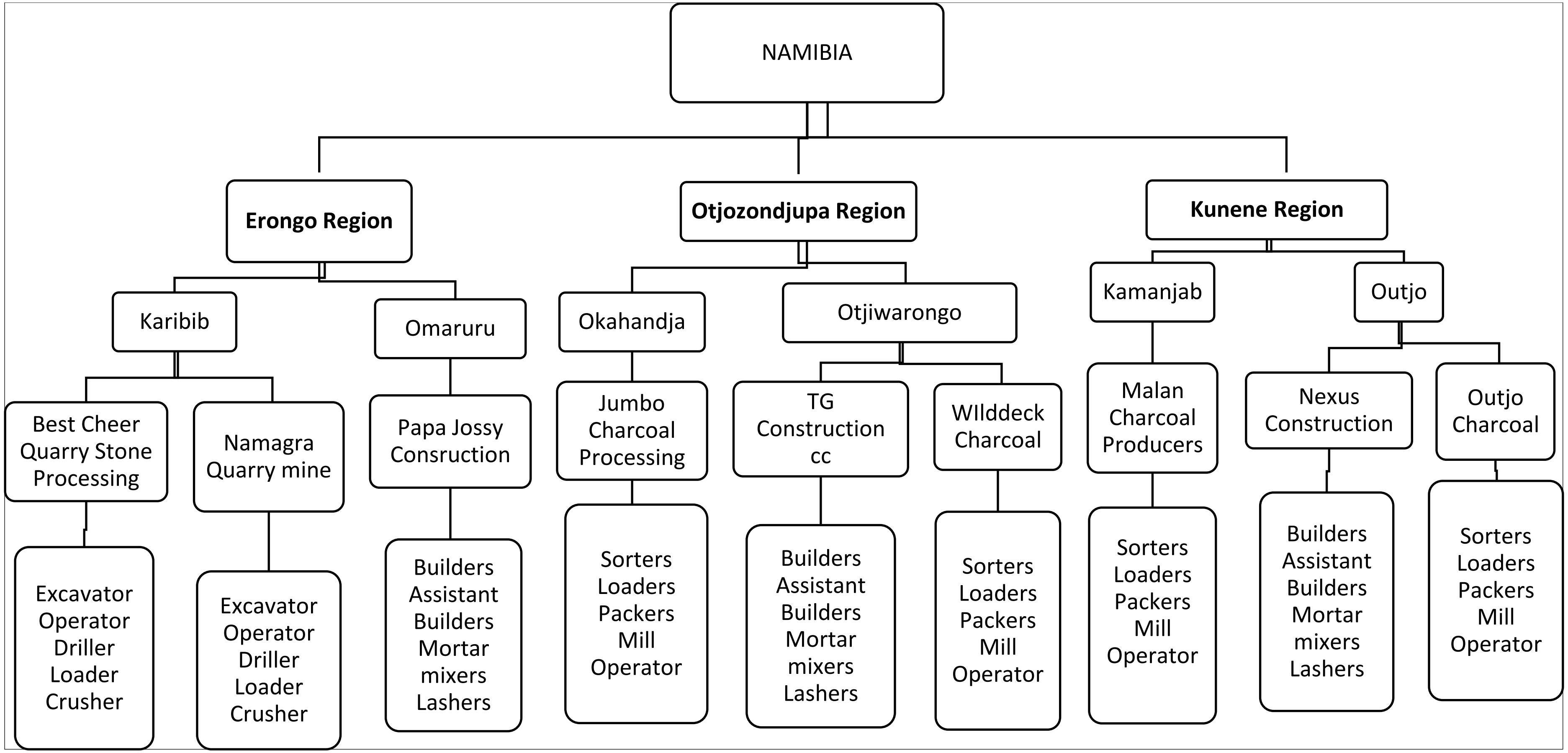

Figure 3.2: Four-tier multistage sampling from the regions, towns, companies, and individual workers (Shihepo, 2024)

The proportional allocation method initially proposed by Bowley (1926) mentions that allocating a given sample size (n) to a different stratum should be proportional to the strata sizes (Dawson, 2022). In this method, the following formula was used to obtain a proportion of each stratum N_x =(n(P))/N, Where N_x is the sample size in each level, n = total sample size of the study, P = population size of the staff in each stratum, N = total population of the study (Leung, 2020). Table 3.2 shows the quarry and allied workers' proposed allocation and sample size for each job category

Table 3.3 Proposed allocation and sample size for each job category

Job category	**Proposed Allocation**	**Proportional sample size**
Clerical Work	65	19
Cleaning	65	19
Drilling	85	25
Excavation	52	16
Ore Loading	90	26
Supervising	35	10
Wire Saw	85	24
Crushing	140	40
Builders	70	20
Mortar mixing	120	35
Charcoal Mill Operator	50	15
Charcoal Loading	50	14
Charcoal Packing	85	24
Charcoal Sorting	120	33
Total	**1112**	**320**

3.2.4.2 Sampling of Managerial Staff

The selection of management was done using a homogeneous purposive sampling technique. Neuman (2021) notes that homogenous purposive sampling focuses on candidates with similar traits or specific characteristics such as jobs, culture, age, or experiences. In this study, the management was selected homogenously based on the similarity in their work, which involves leading, directing, organising, and synchronising mining, construction, and charcoal production activities.

Kumar (2021) suggests that an adequate qualitative sample size should allow data saturation through in-depth exploration and understanding of the phenomena under investigation. Flick (2022) warns that a sizeable qualitative sample may cause complications in analysis, and sample sizes of 10 participants can enable data saturation. This study’s qualitative sample (management participants) was determined through data saturation; thus, when new information was no longer forthcoming. A total of 11 respondents were interviewed in the study. Table 3.3 below shows the number of participants sampled per site

Table 4.3: Number of participants per site

Sample Site	Number of participants
Site 1	1
Site 2	2
Site 3	1
Site 4	1
Site 5	1
Site 6	2
Site 7	1
Site 8	1
Site 9	1
Total	**11**

3.2.5 Research Instruments

This study used self-administered questionnaires to collect data from the quarry and allied workers, whereas semi-structured interviews were used for management.

3.2.5.1 Questionnaire for Quarry and Allied Workers

A questionnaire was the main instrument used for data collection to obtain a broad spectrum of information. The questionnaire comprised closed-ended questions. Closed-ended questions ensured that the participants were restricted to specific categories in their responses for easy data analysis, specifically for quantitative data. Structured questionnaires emphasise how accurately different participants' answers can be compared (reliability). Highly structured questionnaires can collect quantifiable data and work well when one cannot record. An important advantage of the survey questionnaire is its adaptability and ability to reach a large sample. With structured questionnaires, it is possible to get a representative sample, and the results can be used to make statements. The aim of using self-administered questionnaires was to uphold the privacy of the respondents. The suitability of using questionnaires in this study is premised on the fact that they efficiently measure unique data. However, some of the pitfalls of using questionnaires are that the primary researcher has limited control over what happens in the field, and/or the primary researcher cannot control the conditions in which the questionnaire is administered.

3.2.5.2 Questionnaire Design

The questionnaire was designed through a literature review with some items adapted from previous surveys related to respiratory protection. The questions and statements of the questionnaire were grouped and arranged according to the study's specific objectives. The wording and sequence of questions were designed in such a way that the logical flow of ideas from general to specific was maintained. The questionnaire was divided into three sections: Section A: Demographic characteristics of the participants. Section B: Employee respiratory protection assessed how employees were protected against respiratory conditions. Section C: Knowledge, attitudes, and practices towards respiratory protection.

Checklist-type multiple-choice questions consisting of both ordered and partial responses were used. Multiple-choice questions are easy and flexible and help the researcher obtain lean and easy data to analyse (Creswell, 2022). Thus, the research instrument consisted of stem questions and corresponding responses, which the participants could select based on their appropriateness. The checklist-type questions require the participants to make choices from several stated options. In so doing, the participant can select one or more options depending on the question.

3.2.5.3 Interviews and Interview Guide for Managerial Staff

Interviews are qualitative research techniques specifically designed to collect richer qualitative information from a small number of people to explain, better understand, and explore their perspectives on a particular idea, behaviour, experience, programme, or situation (Given, The sage encyclopedia for qualitative research methods, 2021). Semi-structured interviews were conducted with management to obtain consistent and reliable data. During the interview, each participant was asked the same question in the same order. Open-ended questions allowed the researcher to obtain some hidden information that closed-ended questions cannot elicit. To obtain in-depth responses, an interview guide was designed to keep the interview session centred on the research objectives. This maintained continuity through the various interviews. Conversations were written entirely and continue providing raw data for organised analysis. The initial stage of the semi-structured interviews sought individual, in-depth, detailed information from the respondents. The second phase of the semi-structured interviews assisted with clarification and confirmation from the initial respondents

3.2.6 Data Collection

Before the data collection process, the researcher obtained ethical clearance and approval to conduct the study from the Namibia University of Science and Technology, with ethical clearance from the Ministry of Health and Social Services and the selected companies. Data was collected as follows.

3.2.6.1 Quantitative Data Collection (Questionnaires*)*

Questionnaires were researcher/self-administered using the four multi-tier sampling methods. The researcher approached the participants at their workplaces during convenient times, such as break (tea) time and lunch breaks. Before administering the questionnaire, introductions were made followed by a written informed consent form which was orally reinforced in seeking the participant's permission. If the participant agreed, then the questionnaire was administered.

Data collection through self-administered questionnaires (Annexure B) commenced from November 2022 to December 2022. Since the data was collected from different geographical locations, two research assistants were recruited and trained to collect the data from each site. The questionnaires were distributed on weekdays, thus from Monday to Friday, mainly during break time (around 10h 00) and lunchtime (13h 00-14h 00). The research assistants would seek permission from each participant using a written consent form (Annexure A). Each participant was invited to a private area to ensure confidentiality and limit environmental disturbances, such as the noisy background, to enhance maximum concentration. Only consenting participants were given the questionnaire to complete and returned it instantly after completion for data entry. In some instances, the participants were given the questionnaires to complete during their own time and surrender after completion; a maximum of 5 days was given. Each session lasted approximately 25 minutes, with the researcher and her assistants, in some cases, interpreting some of the questions that seemed incomprehensible to the respondent, thus bolstering their understanding and improving the data quality.

3.2.6.2 Qualitative Data Collection (Interviews)

Qualitative data collection was enabled through semi-structured interviews conducted during weekdays except on Mondays and Fridays, as directed by the pilot study. Most of the interview sessions were conducted during lunch hour (between 13h00-14h00), and a few were conducted after 17h00 as per the respondents' arrangement of free time. Before the interviews, participants were invited, appointments were made telephonically, and reminders were sent. All the interviews were conducted at the respondent’s workplace. Environmental disturbances were checked before each interview session, and all the offices that conducted the interviews offered privacy and were free from disturbances and destruction, such as background noise. (Leavy, 2021) advises that while preparing for an interview, the researcher should ensure the least possible disturbance and explain the research aim to the participant to ensure confidentiality. Interviews with respondents may be suitable in a pleasant setting where respondents do not experience constrained or unpleasant exchange intelligence (Leavy, 2022). Non-verbal gestures were also noted as they emphasised some areas the participants explained, which aided the researcher. According to Creswell and Creswell (2022), during interviews, the interviewer must take note of non-verbal communication as it strengthens verbal communication.

3.2.7 Data Presentation and Analysis

Considering that this study employed a mixed methodological approach (qualitative and quantitative), data analysis was accomplished in the following ways:

3.2.7.1 Statistical Analysis

Quantitative data was entered using the numerical coding recording and the Statistical Package for Social Sciences (SPSS) version 28 computer software. Descriptive statistics, correlations, and regression models were used to analyse the quantitative data based on the assessed variable. Correlation analysis quantified associations between dependent and independent variables, and regression assessed the relationship between one or more outcome variables at a 95% confidence interval (Williams, Wiggins, & Vogt, 2022).

3.2.7.2 Thematic Analysis of Interview Data

Qualitative data was analysed through thematic analysis, a systematic method of breaking down and organising rich data by tagging individual observations and quotations with appropriate codes, to facilitate the discovery of significant themes (Given, The sage encyclopedia for qualitative research methods, 2021). Thematic analysis is the most usual form of analysis in qualitative research as it stresses pinpointing, examining, and recording patterns (or "themes") within data. As indicated by Neuman (2021), thematic analysis is achieved through six steps, which are as follows: (1) data familiarisation, (2) code generation, (3) theme searching (among codes), (4) theme reviewing, (5) theme defining and naming, and (6) final write up.

3.3 Particle Filtration Efficacy Experiment of Masks/Filters

A particle filtration efficacy (PFE) laboratory experiment was conducted on the filters/masks. The experiment on the effectiveness of the nose mask workers use to protect their health was conducted at the air and dust laboratory, Centre for Scientific and Industrial Research (CSIR) in South Africa. Examples of the evaluated masks are provided in Figure 3.3. The efficacy of masks in filtering dust particles was evaluated using the dry sampling method. The PFE test evaluated the nonviable particle retention or filtration efficiency of filter media and other filtration devices at the sub-micron level. Seven N95 dust masks were submitted in sealed bags with samples marked as Site A, Site B, Site C, Site D, Site E, Site F, and Site G. An N95 respirator is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. The edges of the respirator are designed to form a seal around the nose and mouth.

Figure 3.3: Dust masks used in dust filtration assessment

The dry-sampling method partially incorporates the method for sampling silica dust used as calibration samples for silica analysis. The samples (dust masks) were combined/placed in a dust-generating glass chamber (Figure 3.4), and laboratory filters were used to measure the quantity of dust flowing through them. The masks were sampled for optimal times of 1 and 5 minutes, respectively.

Figure 3.4: Dust masks combined in a dust-generating glass chamber

The following test was conducted on the dust samples.

3.3.2 Gravimetric Weighing (Pre and Post)

Gravimetric analysis is a method for sampling respirable and inhalable dust particles. In this process, seven PVC filters were pre-weighed on a gravimetric microbalance using the MDHS 14/4 international procedure. The weighing took place in a temperature and humidity-controlled room. The filters were preconditioned overnight, with three reference blank filters used to account for any weight variations produced by the circumstances. The post-run samples were weighed after sampling, together with the reference blanks.

3.3.3 Sampling (Masks Testing)

Testing of dust masks was done with a flow rate of ± 2.2 L/min using the following apparatus

- Personal sampling pumps
- A flow meter used for calibrating the pumps
- 25ml cassette fitted with a cyclone for the collection of dust
- Arizona NIST dust with a certified median size of 31.8µm
- Dust cloud generator made with glass. The lid of the chamber consists of symmetrical holes through which a cyclone sampler can be suspended

Each dust mask was placed inside the glass chamber and sealed with tape to prevent leaks, as shown in images A-F in Figure 3.5.

A **B** **C**

D E F

Figure 3 4: Mask testing procedure

Image A-F: Shows the sampling setup during the testing of the masks; from A to D, shows the dust glass chamber, personnel pump, and how the mask was fitted on the glass. Figure E is the 25mm cassette used to capture the dust fitted with the cyclone; the cassette consists of a PVC filter inside. Image F is the Arizona dust generated to pass through the mask to measure its effectiveness.

A small quantity (approximately 1-5 g) of Arizona National Institute of Standards and Technology (NIST) dust was put in the chamber bowl. A sampling pump was attached to the sampler, and the volumetric flow rates were set at ± 2.2 L/min. Cyclones were attached to the chamber's lid with samplers and put on top. A jet of compressed air was directed at the bowl's side arms for a few seconds, and about 30-60 seconds was allowed for the agglomerates to settle out of the dust cloud. To assess the mask's efficiency while exposed to dust, samples were taken at frequencies between 1 minute and 5 minutes, respectively. Filters were reweighed to determine the loading as per 4.1.

3.3.4 Particle Size Analyser

A particle size analyser (PSA) was used to determine the average particle size of the bulk sample. The PSA used the laser light scattering technique to determine the particle size in the range from 0.1 to 500µm. The sample is dispersed in aqueous media.

3.4 Desktop approach/ secondary research

Secondary research or desktop research involves using already existing data. Secondary research includes published research materials in public libraries and websites, and data from surveys already filled in and from government and non-governmental agencies. This study reviewed Namibian regulations and legislation guiding the respiratory protection of quarry and allied workers against international guidelines, regulations, and legislation that are thought to be "best practices" in protecting respiratory conditions. The following legal provisions were reviewed:

- The Labour Act of 2007
- Public Health Act of 2015

3.5 Framework Development

The development of the framework was guided by study findings obtained through questionnaires from workers, interviews from management, PFE experiment results, and the review of Namibian legal provisions. Figure 3.5 shows the framework development process

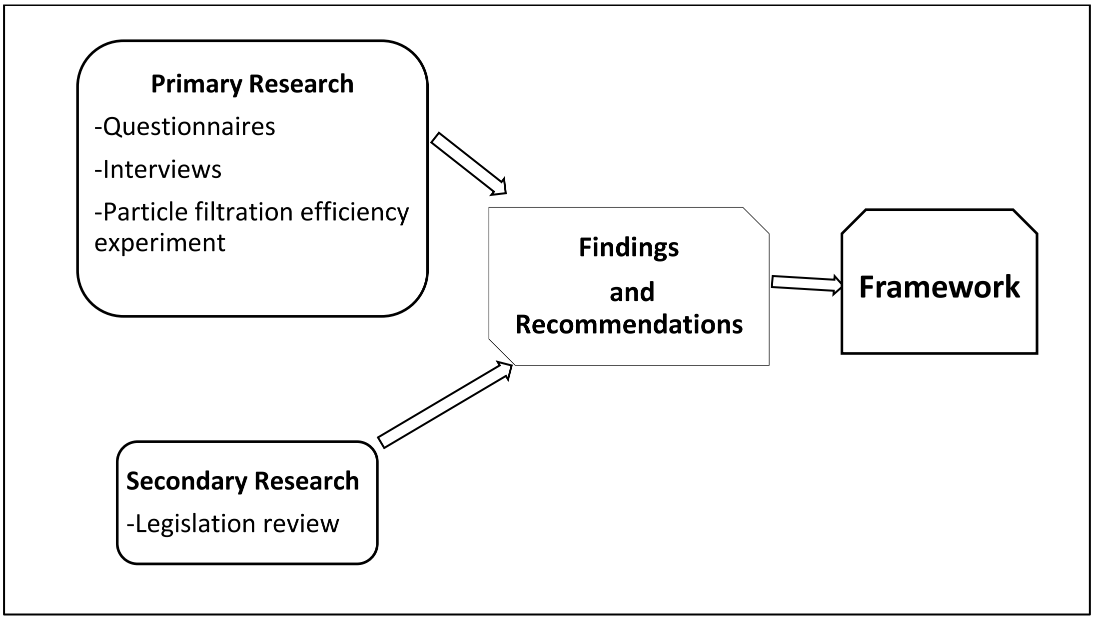

Figure 3.5: Respiratory framework protection framework development process

3.6 Pilot Study

A pilot test was conducted in Otavi, with 5% of the study sample being pretested with the questionnaire and the interview guide. The pilot test was carried out on quarry and allied workers from Sargberg Charcoal in August 2022, with participants with characteristics similar to those selected for the main study.

The pilot study allowed problem-solving strategies and thus paved the way for a successful data collection process and final research. The data collection process had some challenges posed by the questionnaire, including repetitive and vague questions. That is, the order of the questions and wording, and in some instances, the range of multiple-choice answers, were not in tandem. This proved a challenge in collecting accurate and credible information, as the participants did not seem pleased with the questionnaire. Pilot studies may also try to identify potential practical problems in following the research procedure (Williams, Wiggins, & Vogt, 2022). Some questions were reworded to rectify the questionnaire problems, and repetitive questions were discarded. Additionally, the range of responses was revised with some added to establish replies that gave the required information.

Another hindrance shown by the pilot study was the reluctance of some participants to take part, thereby forcing the researcher to look for other willing respondents. The pilot study enabled the investigator to develop participant approach skills, effectively recruiting participants for the main study. Other hurdles were experienced when some participants failed to understand the questions, prompting the researcher and the assistants to be always available to clarify grey areas if the need arose for participants who did not understand. The initial distribution and collection of the questionnaires were tested, proving that questionnaires would be distributed during break times and lunch.

3.7 Measures to Ensure Reliability and Validity

3.7.1 Validity

External validity, which deals with the generalisability of findings of study populations, was ensured by adopting a probabilistic sampling approach and using a representative sample of quarry and allied workers (Leung, 2020). All the quarry and allied workers who met the research criteria completed the same questionnaire. Validity was increased by exploring multiple sources of evidence and engaging research experts and key participants in reviewing the research instrument to avoid misinterpretations. Given this point, validity was guaranteed through in-depth scrutiny of the standing literature to classify conceptual dimensions and questionnaire evaluation by a series of research specialists from the Namibia University of Science and Technology and my research supervisors.

3.7.2 Reliability

Reliability refers to how likely the findings can be repeated if the study were to be done a second time it would yield the same results (Leung, 2020). To ensure reliability, the questionnaire was subjected to a pilot test to assess the questions' relevance, sensitivity, and acceptability. The outcome of the pilot study validated the questionnaire as consistency and accuracy were portrayed. This helped to determine the effectiveness of conducting the proposed study, thereby allowing for modifications to suit the study's objectives.

3.8 Data Trustworthiness

Data trustworthiness aims **to** back the findings' argument by inquiring whether it deserves attention (Creswell, Vicki, and Plano, 2020). Neuman (2021) suggests that data trustworthiness is entrenched in ensuring valid data interpretation through dependability, credibility, conformability, and transferability.

3.8.1 Credibility

Flick (2022) mentions that credibility is realised through strategies that uphold honesty from the participants. This study's credibility was ensured by ensuring that only willing and genuine respondents participated. Also, respondents were motivated to be truthful and authentic in all discussions from the onset of each interview session. Thus, integrity was upheld. Research seminars in article writing at NUST/DRIP contributed to the credibility of this study. Two peer-reviewed articles emanated from this study, and a third manuscript was submitted for possible publication.

3.8.2 Transferability

This criterion assesses how the study outcome can be generalised to other individuals' situations in addressing the main issue under study (Dawson, 2022). Transferability was ensured through providing information that exhibited the study population of the managerial staff, the number of quarry and allied workers, and the data collection techniques used.

3.8.2.1 Dependability

Given (2021) regards dependability in a qualitative inquiry as evaluating how the research is carried out in line with the time and analysis techniques**.** Dependability was ensured through elucidating and implementing a robust methodological portrayal, which fully narrates the operational features of data collection and minutes of all field proceedings. This permits the study's repetitiveness.

3.8.2.2 Confirmability

Addresses core issues concerned with findings representing the situation being researched rather than the researcher's beliefs, pet theories, or biases (Dawson, 2022). With the issue of confirmability, the researcher recognised and acknowledged shortcomings and limitations in the study's methods and their potential effects.

3.9 Ethical Considerations

The following ethical guidelines were addressed during this research.

Permission to conduct the study

Ethical Clearance was obtained from the Research Ethics Committee of Namibia University of Science and Technology (FHAS:19/2021) and the Ministry of Health and Social Services (Ref. 22/4/2/3). Ethical approval was obtained from the quarry sites to access data from the quarry sites.

Autonomy

Autonomy depicts respect for human dignity and people's right to act independently. Via informed consent, respondents were granted voluntary participation and provisions to decline participation or withdraw from the research at any time. Signed consent was gained from each participant as the participants needed to comprehend what was essential to make an informed choice before participating in the study.

Confidentiality and Anonymity

Confidentiality means that identifiable information collected from an individual during the research process will not be disclosed without permission (Creswell, 2022). Confidentiality was ensured by not revealing the source of the data. In contrast, anonymity was guaranteed by omitting the identification of information, such as names, on the research instruments instead of numerical and alphabetical coding. All data was held strictly confidential, as the researcher was the only one who knew the source or origin of the data. Subsequently, the data was kept in a password-secured computer that was accessible only to the researcher.

Non-maleficence

This principle pertains to assuring the participants that they will not experience any harm, pain, suffering, or victimisation due to partaking in the study (Kumar, 2021). It was explained to the participants (managerial staff, quarry workers, and allied workers) that they were not liable for punishment, victimisation, or mistreatment following their involvement in the study.

Beneficence

Beneficence pertains to the mandate of promoting benefits accrued from the study (Williams, Wiggins, & Vogt, 2022). In this study, the participants had no direct benefits from their participation; however, there are indirect benefits from the implementation of recommendations as per the study findings.

3.10 Chapter Summary

This chapter outlined the research methodology adopted in the development of a framework for the protection of quarry and allied workers from occupational respiratory illnesses in Namibia. The researcher discussed the research design adopted and gave reasons for choosing the specific design, described the population under study, the sample size used, and the specific sampling techniques applied in selecting the sample. Other issues discussed include data collection procedures and the approach to data analysis. This chapter also discussed the ethical, validity, and reliability issues. The next chapter will discuss the study results according to the phases.

CHAPTER 4: RESULTS

4.0 Introduction

This chapter presents the outcome of the study. The first section presents the socio-demographic data of the participants. The current practices in protecting quarry and allied workers from respiratory infections, KPA of quarry and allied workers on occupational respiratory protection, the particle filtration efficiency of the masks/filters, and a review of the Namibian legal provisions protecting quarry and allied workers from respiratory infections are all discussed in this chapter.

4.1 Respondents' Demographic Characteristics

4.1.1 Demographic Characteristics of Quarry and Allied Workers

In this study, 320 self-administered questionnaires were distributed among quarry and allied workers from three Namibian regions, namely Erongo, Otjozondjupa, and Kunene. Of the 320 distributed questionnaires, 304 were returned, achieving a response rate of 95%. The demographic information of the participants is presented in Table 4.1.

As delineated in Table 4.1, the most dominant age group is 25-34 years with 53% (n=161), trailed by 35-44 years with 26.3% (n=80). Participants aged 55-65 were the least represented with 1% (n=3). There were more males, 74.7% (n=227), than females, 25.3% (n=77), working in quarries and construction sites. Most participants were single, 89.1% (n=271) compared to those who were married, 10.9% (n=33). Most quarry and allied workers attained a secondary school education level of 53% (n=161), followed by primary education of 31.6% (n=96). Only 6.9% (n=21) reached the tertiary level. Almost all 92.1% (n=280) quarry and allied workers were fully employed, whereas only 7.9% (n=24) worked on a part-time basis. The bulk of the participants, 27% (n=134), worked under stone blasting, followed by bagging 18.8% and loading 13.2%. Few individuals, 3%, worked as builders, and 4.3% worked in stone collection, grinding, and polishing. Most quarry and allied workers, 40.1% (n=122), worked for 1-3 years, followed by those working for 4-7 years, 37.2% (n=113). Only 2.6% (n=8) worked for more than 10 years.

Table 4 1: Respondents' Demographic Characteristics

Demographic Variable	Characteristic	Frequency (n)	Percent (%)
Age	18-24 years	40	13.2
	25-34 years	161	53
	35-44 years	80	26.3
	45-54 years	20	6.6
	55-65 years	3	1
	Total	304	100
Gender	Male	227	74.7
	Female	77	25.3
	Total	304	100
Marital Status	Single	271	89.1
	Married	33	10.9
	Total	304	100
Educational Level	None	26	8.6
	Primary level	96	31.6
	Secondary level	161	53.0
	Tertiary level	21	6.9
	Total	304	100.0
Employment Status	Full-time	280	92.1
	Part-time	24	7.9
	Total	304	100
Working Experience	Less than a year	34	11.2
	1-3 years	122	40.1
	4-7 years	113	37.2
	7-10 years	27	8.9
	More than 10 years	8	2.6
	Total	304	100

4.1.2 Demographic Characteristics of Managerial Staff

Table 4.2 shows the demographic information of the ten managerial staff conveniently sampled from the nine sites.

Table 4.2: Demographic information of managerial staff

Participant	Gender	Age	Educational level	Work experience
1	Male	31	Secondary	5 years
2	Male	44	Secondary	8 years
3	Male	36	Tertiary	4 years
4	Male	28	Secondary	4 years
5	Male	34	Secondary	6 years
6	Male	26	Tertiary	5 years
7	Male	35	Secondary	5 years
8	Male	33	Tertiary	4 years
9	Male	45	Tertiary	10 years
10	Male	39	Secondary	8 years

As shown in Table 4.2, all ten respondents were males aged 31 to 45. Most mine managers attained secondary school education, with some attending tertiary education. The mine managers had working experience ranging from 4 to 10 years.

Table 4.3 shows a crosstab of employees' job categories and worksites. The study examined nine sites, with five mainly in quarry mines, while the other four specialised in charcoal production and construction. Site 6 had the highest number of workers, 11.8% (n=36), while site 1 had the least, 10.2% (n=31); the mean number of employees for all nine sites is 33.7. A total of 14 job categories were identified, with crushing having the most workers at 18.3% (n=42), followed by mortar mixing at 10.5%(n=32) and charcoal sorting at 9.9% (n=30). The supervisory role was least represented, with 3.3% (n=10).

Table 4.3: Job category and worksite crosstab

Job category	Worksite									Total
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	
Clerical Work	2(13.3%)	2(13.3%)	2(13.3%)	2(13.3%)	2(13.3%)	2(13.3%)	1(6.7%)	1(6.7%)	1(6.7%)	**15(4.9%)**
Cleaning	2(12.5%)	2(12.5%)	2(12.5%)	2(12.5%)	2(12.5%)	2(12.5%)	1(6.3%)	1(6.3%)	2(12.5%)	**16(5.3%)**
Drilling	5(23.8%)	4(19%)	4(19%)	4(19%)	4(19%)	0	0	0	0	**21(6.9%)**
Excavation	3(23.1%)	3(23.1%)	3(23.1%)	2(15.4%)	2(15.4%)	0	0	0	0	**13(4.3)**
Ore Loading	5(17.2%)	5(17.2%)	5(17.2%)	5(17.2%)	5(17.2%)	4(13.8%)	0	0	0	**29(9.5%)**
Supervising	2(20%)	1(10%)	1(10%)	1(10%)	1(10%)	1(10%)	1(10%)	1(10%)	1(10%)	**10(3.3%)**
Wire Saw	4(17.4%)	3(13%)	4(17.4%)	4(17.4%)	4(17.4%)	4(17.4%)	0	0	0	**23(7.6%)**
Crushing	8(19%)	7(16.7%)	7(16.7%)	7(16.7%)	7(16.7%)	6(14.3%)	0	0	0	**42(13.8%)**
Builders	0	3(15.8%)	2(10.5%)	2(10.5%)	2(10.5%)	5(26.3%)	5(26.3%)	0	0	**19(6.3%)**
Mortar mixing	0	5(15.6%)	5(15.6%)	5(15.6%)	5(15.6%)	7(22%)	5(15.6%)	0	0	**32(10.5%)**
Charcoal Mill Operator	0	0	0	0	0	0	4(30.8)	4(30.8)	5(38.5)	**13(4.4%)**
Charcoal Loading	0	0	0	0	0	0	6(35.3%)	6(35.3%)	5(29.4%)	**17(5.6%)**
Charcoal Packing	0	0	0	0	0	0	8(33.3%)	8(33.3%)	8(33.3%)	**24(7.9%)**
Charcoal Sorting	0	0	0	0	0	0	4(33.3%)	14(46.7%)	12(40%)	**30(9.9%)**
Total	**31(10.2%)**	**35(11.5%)**	**33(10.9%)**	**34(11.2%)**	**32(10.5%)**	**36(11.8%)**	**35(11.5%)**	**34(11.2%)**	**34(11.2%)**	**304(100%)**

4.2 Dust Exposure at Work

The study's results on the proportion of quarry and allied workers who were exposed to dust at work are as presented in Figure 4.1 below:

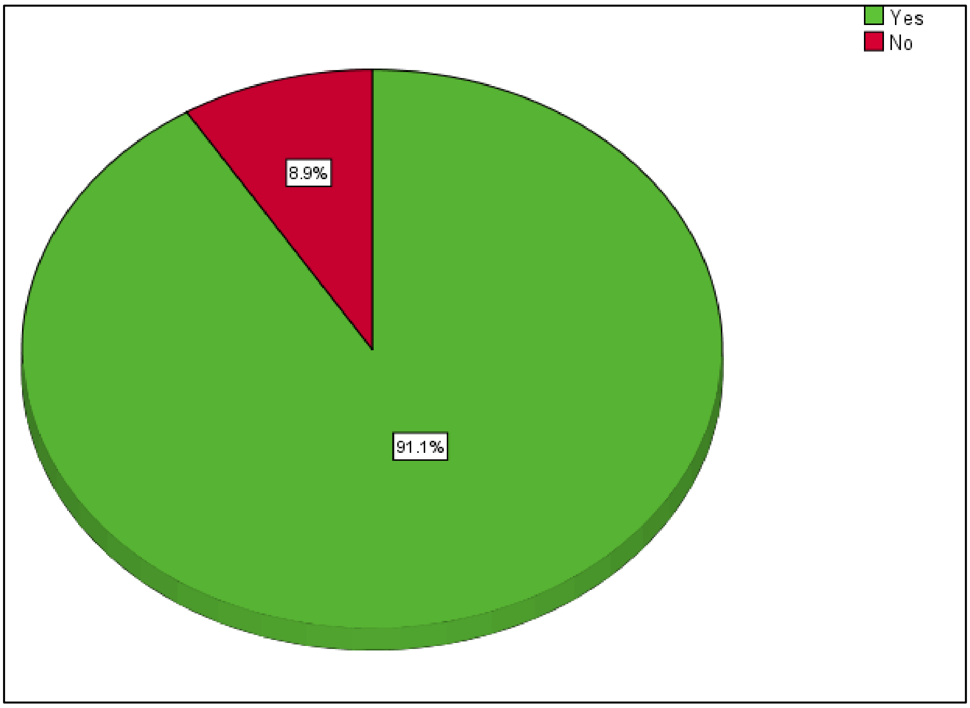

Figure 4.1: Proportion of quarry and allied workers exposed to workplace dust

As shown in Figure 4.1, most quarry and allied workers (91.1%) were exposed to dust at work, while only 8.9% were not.

4.3 Protection of Quarry and Allied Workers from Respiratory Conditions and Infections

The current protection of Namibian quarry and allied workers from respiratory conditions and infections is presented using the hierarchical hazard control model. The hierarchy of controls ranks five levels of actions to reduce or remove hazards from the most to least effective. Premised on this study's outcomes, 3-level action controls for reducing respiratory hazards have been identified from the most to least effective as engineering controls, administration controls, and use of PPE/C.

4.3.1 Engineering Controls

Water mists and sprays (wet drilling) are an effective engineering control measure to protect employees who are exposed to dust in quarry mines and construction sites. The study sought to find out the application of water mists and wet drilling to protect quarry and allied workers in Namibia. As shown in Table 4.4 below, most of the participants, 87.1% (n=265), indicated that water sprays were not used to reduce the amount of dust emitted into the atmosphere due to the mining and construction processes. The application of water mists was not a common practice in protecting quarry and allied workers, as almost all the participants, 98% (n=298), failed to acknowledge.

Table 4.4: Engineering controls used in protecting quarry and allied workers

Engineering Control Measure	Yes		No	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Water Sprays (wet drilling)	39	12.9	265	87.1
Water Mists	6	2	298	98

4.3.2 Administrative Controls

The study assessed the application of administrative controls in protecting quarry and allied workers and revealed the following outcomes on educational/training programs and medical surveillance measures.

4.3.2.1 Educational /Training Programmes

Employee education/training is a critical element of any complete protection of employees from workplace hazards, as it imparts information on how to protect themselves and their co-workers. This study assessed health and safety training among quarry and allied workers in Namibia and revealed the following results in Table 4.5 below.

Table 4.*5*: Employee educational awareness/training

Question	Response	Frequency(n)	Percent (%)
Are you aware of any respiratory protection, health, and safety guidelines or company policies	Yes	119	39.1
	No	185	60.9
	Total	304	100
Are you trained on the importance, use, and care of PPE/C aligned with respiratory protection	Yes	74	24.3
	No	230	75.7
	Total	304	100

Less than a quarter of the participants, 24.3% (n=74), were trained on the importance of PPE/C, while the majority, 75.7% (n=230), did not receive such training. Subsequently, most quarry and allied workers, 60.9% (n=185), did not know any guidelines or company policies on PPE/C, while more than a quarter, 39.1% (n=119), were knowledgeable.

4.3.2.2 Medical Surveillance Measures

The study assessed the existence of a medical surveillance program as part of a respiratory protection initiative. As shown in Table 4.6, all the quarry and allied workers (100%) did not undergo pre-employment medical checkups. Upon employment, only 11.8% (n=36) of the workers acknowledged going for periodic medical examinations compared to 88.2% (n=268) who did not.

Table 4.6: Employee pre- and periodic medical examination

Type of medical examination	Yes		No	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Pre-employment medical examination	0	0	304	100
Periodic medical examination	11.8	36	268	88.2

4.3.2.3 Hygiene Facilities

The study sought to assess the presence of hygiene-enabling facilities, as they are key in protecting employees from respiratory infections and conditions. Table 4.6 shows the level of hygiene facilities among quarry and allied workers

Table 4 .7: Hygiene enabling facilities

Control Measure	Yes		No	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Adequate handwashing facilities	132	43.2	172	56.8
Separate sex showers with hot and cold water	21	6.9	283	93.1
Clean change areas with separate storage facilities for PPE/C and personal clothes	43	14.1	261	85.6

As shown in Table 4.7, 56.8% (n=172) of quarry and allied workers did not have adequate handwashing facilities. Consequently, the majority, 93.1% (n=283), were not provided with separate sex showers with both hot and cold water, and more than three-quarters, 85.6%(n=261), were not offered clean changing areas with separate facilities for PPE/C and personal clothing.

4.3.3 Personal Protective Equipment/Clothing

4.3.3.1 Provision and Experiences Associated with PPE/C Usage

The provision of PPE is key to protecting quarry and allied workers from respiratory infections and conditions. Table 4.8 shows the questions and responses of quarry and allied workers concerning the provision and experiences with the usage of PPE.

Table 4.8: Provision and experiences associated with PPE/C usage

Question	Response	Frequency(n)	Percent (%)
Are you provided with PPE/C?	Yes	146	48
	No	158	52
	Total	304	100
If YES, do you pay for PPE/C	Pay	15	10.3
	Free of charge	131	89.7
	Total	146	100.0
How do you often use PPE/C	Always	197	64.8
	Sometimes	107	35.2
	Total	304	100
Do you experience problems in using PPE/C	Yes	109	35.9
	No	195	64.1
	Total	304	100

The study revealed that more than half of the quarry and allied workers, 52% (n=158), were not provided with PPE/C while carrying out their duties at work. Of those provided with PPE/C, 10.3% (n=15) paid for their PPE/C, while the majority, 89.7% (n=131), were given it free of charge. The use of PPE/C among quarry and allied workers was inconsistent, with 35.2% (n=107) occasionally using PPE/C, while more than half, 64.8% (n=197), always used it. Less than half of the participants, 35.9% (n=109), experienced problems using PPE/C, while the majority, 64.1% (n=195), did not encounter any challenges.

4.3.3.2 Type of PPE/C Provided

The study sought to find out the appropriateness of PPE/C provided to quarry and allied workers aligned to protection against respiratory infections and conditions. Figure 4.2 shows the type of PPE/C provided to Namibian quarry and allied workers.

As shown in Figure 4.2, a small portion of the employees (3.9%) were given respirators as well, and 7.6% were given a combination of respirators, masks, and overalls. The majority (60.5%) were given overalls only, while 13.2% were given masks only.

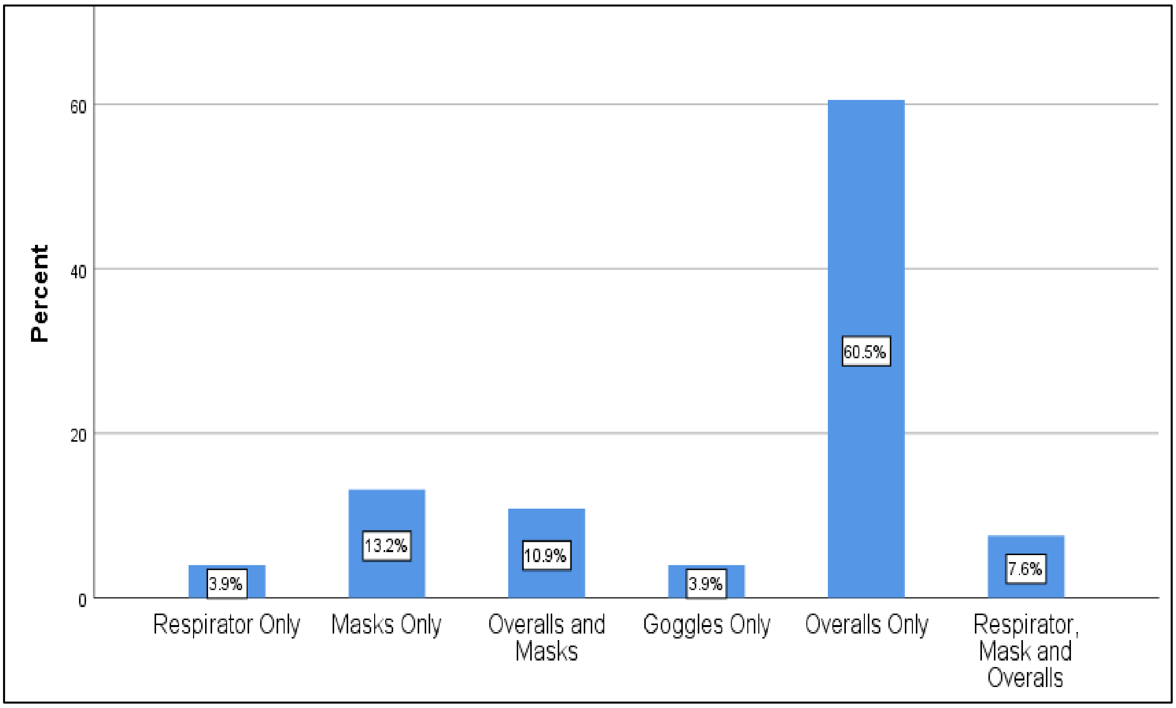

Figure 4.2: Type of PPE/C provided

4.3.3.3 Result of the Respirator Fit Testing

Respiratory protection standards require test fitting of respirators before use. Considering this requirement, the study sought to determine if quarry and allied workers are test-fitted with respirators before use. The findings showed that out of the employees supplied with respirators, none (100%) obtained respirator fit testing.

4.3.3.4 Conditions Interfering with Respirator Use

Certain conditions, such as excessive facial hair, including stubble and wide sideburns, can compromise the effective use of respirators. Premised on these conditions, the study questioned the presence of such conditions among quarry and allied workers. The study findings showed that almost half of the employees, 55% (n=167), had excessive facial hair, including stubble and wide sideburns, which interferes with the respirator seal and ultimate protection from dust inhalation.

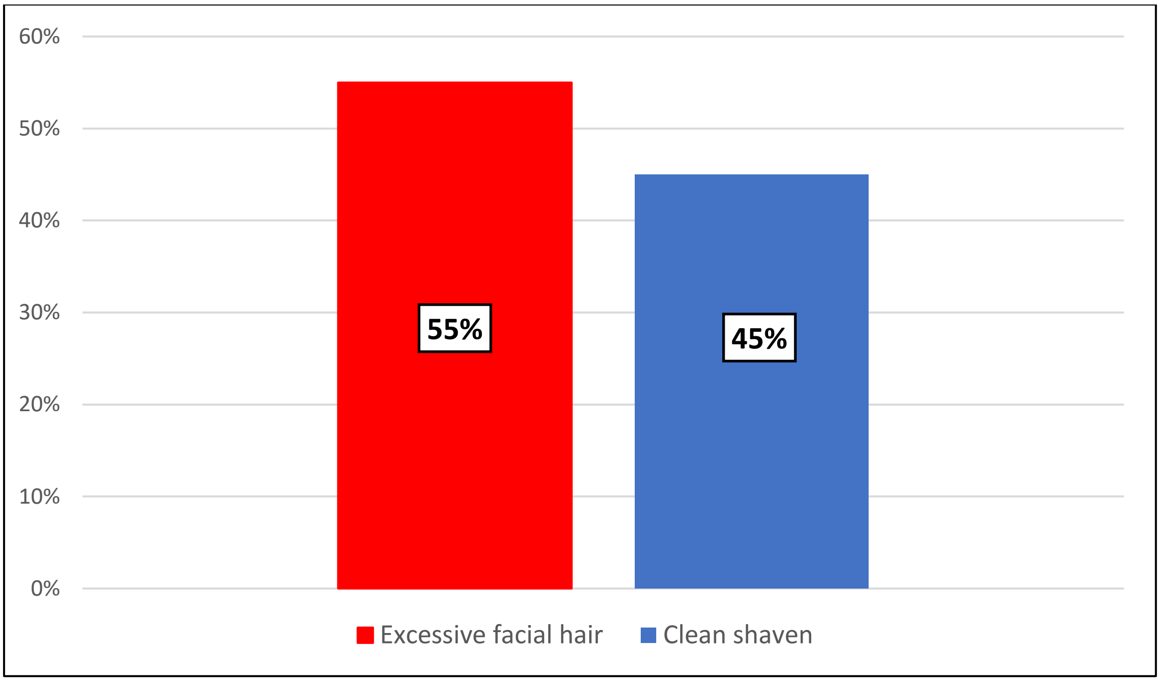

Figure 4.3: Conditions Interfering with Respiratory Use

4.3.4 Level of Employee Respiratory Protection

The study sought to determine employee respiratory protection level by attaining the mean (average) of all controls (engineering controls, administrative controls, and PPE/C use) used in protecting employees. As shown in Table 4.9, the level of respiratory protection for employees was 20.3%. According to the EU Occupational Safety and Health Directives, this is a low degree of compliance as the indicator ranges from 20-39%.

Table 4.9: Summarised table on the average level of quarry and allied workers' respiratory protection by class and type of control

Class of Control		Type of Control	Yes		No	
			Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Engineering Controls		Water Sprays	39	12.9	265	87.1
		Water Mists	6	2	298	98
Administrative Controls	Training	Awareness of health and safety guidelines	119	39.1	185	60.9
		Training on the importance, use, and care of PPE/C	74	24.3	230	75.7
	Medical Surveillance	Pre-employment medical check-up	0	0	304	100
		Periodic medical examination	36	12	268	78
	Hygiene Facilities	Adequate handwashing facilities	132	43.2	172	56.8
		Separate gender showers are supplied with hot and cold water	21	6.9	283	93.1
		Clean change areas with separate storage facilities for PPE/C and personal clothes	43	14.1	261	85.6
PPE/C		Provision of PPE/C	146	48	158	52
Average Employee Protection Level			62	20.3	242	78.7

4.3.5 Association between Employee Level of Respiratory Protection with Individual and Work-Related Factors

A Chi-square test was performed to ascertain the association between the level of employee respiratory protection and the following individual factors: age, gender, marital status, employment status, working experience, job category, frequency of PPE/C utilisation, and educational level work site.

Table 4.10: Association between individual and work-related factors with employee respiratory protection level

Variable	Value	df	Asymptotic Significance (2-sided)
Age	5.618	3	0.006
Gender	0.053	1	0.818
Marital status	0.338	1	0.561
Employment status	7.592	1	0.000
Working experience	12.275	4	0.015
Job category	37.742	9	0.000
Frequency of PPE/C utilisation	0.708	1	0.004
Educational level	68.517	3	0.000
Worksite	282.178	8	0.000

As shown in Table 4.10, the Pearson Chi-Square test result portrays a statistically significant association between employee respiratory protection and employment status at $\chi^2(1) = 7.592$, $p = 0.000$; employee respiratory protection and job category at $\chi^2(9) = 37.742$, $p = 0.000$; employee respiratory protection and educational level at $\chi^2(3) = 68.517$, $p = 0.000$; employee respiratory protection and worksite at $\chi^2(8) = 282.178$, $p = 0.001$. However, there was no statistically significant relationship between employee respiratory protection and age at $\chi^2(3) = 5.618$, $p =0.006$, employee respiratory protection and gender at $\chi^2(1) = 0.053$, $p =0.818$, employee respiratory protection and working experience at $\chi^2(4) = 12.275$, $p =0.015$.

4.3.6 Correlation of Individual and Work-Related Factors with the Level of Employee Respiratory Protection

A Pearson correlation was performed to establish the relationship between selected individual and work-related factors (work site, age, gender, marital status, religion, level of education, employment status, working experience, job category) and the level of employee respiratory protection as indicated in Table 4.10.

Table 4.11: Individual and work-related factors correlation with employee respiratory protection level

Correlation variables	Pearson Correlation
The level of employee respiratory protection and the worksite	.700**
Level of employee respiratory protection and age	.142*
Level of employee respiratory protection and gender	0.013
Level of employee respiratory protection and marital status	-0.033
Level of employee respiratory protection and employment status	0.057
Level of employee respiratory protection and working experience	0.036
Level of employee respiratory protection and job category	.331**
Level of employee respiratory protection and training	-.841*
The level of employee respiratory protection and educational level	-.424**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

There was a strong positive correlation between employee respiratory protection and worksite (r = 0.7) at 99% CI (2-tailed), as well as a weak positive association between employee respiratory protection and age (r = 0.142) at 95% CI. The level of employee respiratory protection showed a weak positive correlation with job category (r=0.331) at 99% CI, a strong positive relationship with training (r=0.841) at 95% CI, and a moderately weak association with the level of education (r=0.424) at 99% CI. There was no significant correlation between the level of employee respiratory protection and gender (r=0.013), with employment status (r = -0.057), marital status (r = 0.033), and working experience (r = 0.036).

4.3.7 Multiple Regression Analysis of Employee Respiratory Protection Level with Selected Individual and Work-Related Factors

Selected individual and work factors were assessed in a standard regression analysis to predict the level of employee respiratory protection. Table 4.12 provides an overview of the model summary analysis.

Table 4.12: Model Summary analysis of employee respiratory protection level with selected individual and work-related factors

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
					F Change	df1	df2	
0.72	0.518	0.501	0.285	0.518	31.467	10	293	0.000

Predictors: (Constant), work site, age, gender, marital status, religion, level of education, employment status, working experience, job category.

The prediction model summary was statistically significant, F (10, 293) = 31.467, p = 0.000 as more than half (52%) of the selected individual factors accounted for the level of employee respiratory protection (R^2 = 0.501, Adjusted R^2 = 0.518). There was a medium-high degree of correlation denoted by R=0.72. These findings imply that selected individual and work-related factors highly influenced the level of employee respiratory protection.

4.3.8 Raw and Standardised Regression Analysis of Employee Respiratory Protection Level with Individual and Work-Related Factors

A linear multiple regression analysis was performed to ascertain if selected individual and work-related factors predict the level of employee respiratory protection.

Table 4.13: Raw and standardised regression correlation coefficients of selected individual and work-related factors as predictors of employee respiratory protection

	Unstandardised Coefficients		**Standardised Coefficients**	**t**	**Sig.**	**95% Confidence Interval for B**	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.344	0.149		9.021	0.000	1.050	1.637
Worksite	0.128	0.008	0.818	15.113	0.000	0.112	0.145
Age	0.018	0.024	0.037	0.766	0.444	-0.029	0.065
Gender	-0.026	0.040	-0.028	-0.655	0.513	-0.104	0.052
Marital status	0.053	0.056	0.041	0.951	0.342	-0.057	0.163
Level of education	-0.060	0.050	-0.051	-1.206	0.000	-0.158	0.038
Religion	0.060	0.063	0.040	0.951	0.342	-0.064	0.184
Employment status	-0.023	0.022	-0.051	-1.044	0.003	-0.066	0.020
Working experience	-0.016	0.005	-0.153	-2.922	0.001	-0.027	-0.005
Job category	0.001	0.036	0.001	0.018	0.985	-0.070	0.072

Dependent Variable: Employee respiratory protection
Independent Variables: worksite, age, gender, marital status, level of education, religion, employment status, working experience, job category.

As shown in Table 4.13, the work site bears a statistical significance at p=0.00 ($p<0.05$) to employee respiratory protection. Also, statistically significant influencing employee respiratory protection at 95% CI are the level of education (p=0.000), employment status (p=0.003), and working experience (p=0.001). That is, premised on the regression model, level of education, working experience, and worksite, predicts or influences how quarry and allied workers are protected from respiratory infections and conditions. On the other hand, employee respiratory protection was not determined by age (p=0.444), gender (p=0.513), marital status (p=0.342), religion (p=0.432), and job category (p=0.985).

4.4 Workers' Knowledge Level, Attitudes, and Practices

The study sought to establish quarry and allied workers' level of knowledge, attitudes, and practices aligned to respiratory protection as delineated by Table 4.14 below:

Table 4.14: Workers' knowledge level, attitudes, and practices

Variable		Frequency	Per cent
Knowledge	Adequate	101	33.2
	Inadequate	203	66.8
	Total	304	100.0
Attitudes	Positive	130	42.8
	Negative	174	57.2
	Total	304	100.0
Practice	Good	92	30.3
	Bad	212	69.7
	Total	304	100

As depicted in Table 4.14 above, most of the workers, 66.8% (n=203), had inadequate knowledge of respiratory protection compared to 33.2% (n=101) who had adequate knowledge. More than half of workers, 57.2% (n=174), had negative attitudes toward respiratory protection compared to 42.8% (n=130) who had positive attitudes. Subsequently, most workers, 69.7% (n=212), had bad respiratory practices. These findings imply that inadequate knowledge of respiratory protection negatively influenced employee attitudes and associated practices.

Table 4.15 shows the workers' knowledge, attitudes, and practices cross-tabulation. All workers 100% (n=174) with inadequate knowledge had negative attitudes towards respiratory protection. More than three-quarters of workers, 77.6% (n=101), with adequate knowledge, had positive attitudes. This finding reflects the influence of knowledge on employee attitudes towards respiratory protection. Almost all workers, 95.8% (n=203), bearing inadequate knowledge, had bad practices aligned to respiratory protection. All workers, 100% (n=92), who had positive attitudes also had good practices towards respiratory protection. However, most employees, 82.1% (n=174), had negative attitudes and bad practices.

Table 4 .15: Workers' knowledge, attitudes, and practices cross-tabulation

		Knowledge		
		Adequate	Inadequate	Total
Attitudes	Positive	101(77.6%)	29(22.4%)	130(42.7%)
	Negative	0	174(100%)	174(57.3%)
	Total	101(33.2%)	203(66.8%)	304(100%)
Practice	Good	92(100%)	0	92(30.2%)
	Bad	9(4.2%)	203(95.8%)	212(69.8%)
	Total	101(33.2%)	203(66.8%)	304(100%)
		Attitudes		
		Positive	Negative	Total
Practice	Good	92(100%)	0	92(30.2%)
	Bad	38(17.9)	174(82.1)	212(69.8%)
	Total	130(42.7%)	174(57.3%)	304(100%)

4.4.1 Association of Workers' Knowledge, Attitudes and Practices

The study assessed the relationship among the workers' knowledge, attitudes, and practices, as shown in Table 4.16.

Table 4.16: Association of workers' knowledge, attitudes, and practices

	Practice	**Knowledge**	**Attitudes**
Practice	1		
Knowledge	.934**	1	
Attitudes	.762**	.816**	1

** Correlation is significant at the 0.01 level (2-tailed)

As shown in Table 4.16, there is a very high positive correlation between knowledge and practice (*r*=0.934), between knowledge and practice (*r*=0.816), as well as a high positive association between practice and attitudes (*r*=0.762).

4.4.2 Multiple Regression Analysis of Factors Influencing Employee Knowledge

Individual and work-related factors were subjected to standard regression analysis to predict employee knowledge of respiratory protection. Table 4.17 shows the multiple regression model summary.

Table 4.17: Model summary of multiple regression analysis of factors influencing employee knowledge

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
					F Change	df1	df2	
.869[a]	0.755	0.746	0.238	0.755	90.132	10	293	0.000

Predictors: (Constant), site, age, gender, marital status, level of education, religion, employment status, working experience, job category, training status.

The prediction model summary was statistically significant, F (10, 293) = 90.132, p=0.000, and accounted for approximately 75% of the variance of individual and work-related factors on employee knowledge (R^2 = 0.755, Adjusted R^2 = 0.746). A high degree of correlation was denoted (R=0.869). Hence, individual and worker-related factors highly predict employee knowledge of respiratory protection.

4.4.2.1 Raw and Standardised Regression of Individual and worker-related Factors on employee knowledge

A raw and standardised regression analysis was performed to ascertain if site, age, gender, marital status, level of education, religion, employment status, working experience, job category, and training status predict the employee's knowledge of respiratory protection. The results are shown in Table 4.18.

Table 4.18: Raw and standardised regression of individual and worker-related factors on employee knowledge

	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.276	0.130		9.782	0.000	1.019	1.533
Site	0.157	0.007	0.858	21.656	0.000	0.143	0.172
Age	0.002	0.020	0.003	0.101	0.920	-0.037	0.041
Gender	0.069	0.033	0.064	2.100	0.037	0.004	0.134
Marital status	-0.141	0.047	-0.093	-3.036	0.003	-0.233	-0.050
Level of education	-0.117	0.020	-0.189	-5.999	0.000	-0.156	-0.079
Religion	0.006	0.041	0.004	0.146	0.884	-0.075	0.087
Employment status	0.030	0.053	0.017	0.578	0.563	-0.073	0.134
Working experience	-0.045	0.018	-0.086	-2.469	0.014	-0.081	-0.009
Job category	-0.020	0.005	-0.166	-4.440	0.000	-0.029	-0.011
Training status	0.118	0.030	0.117	3.932	0.000	0.059	0.178

Dependent variable: Knowledge

As shown in Table 4.18, work site (*p*=0.000), marital status (*p*=.003), level of education (*p* = 0.000), job category (*p*=0.000), and training status (*p*=0.000) all bear statistical significance at 95% CI in predicting the level of employee knowledge on respiratory protection.

4.4.3 Multiple Regression Analysis of Factors Influencing Employee Attitudes

Individual and work-related factors were subjected to standard regression analysis to predict employee attitudes toward respiratory protection. Table 4.19 shows the multiple regression model summary.

Table 4.19: Model summary of multiple regression analysis of factors influencing employee attitudes

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
					F Change	df1	df2	
.879[a]	0.773	0.766	0.240	0.773	99.929	10	293	0.000

Predictors: (Constant), site, age, gender, marital status, level of education, religion, employment status, working experience, job category, training status

The prediction model summary was statistically significant, F (10, 293) = 99.929, *p*=0.000, and accounted for approximately 77% of the variance of individual and work-related factors on employee attitudes (R^2 = 0.773, Adjusted R^2 = 0.766). A high degree of correlation was denoted (*R*=0.879). Hence, the individual and worker-related factors highly predict employee attitudes on respiratory protection.

4.4.3.1 Raw and Standardised Regression of Individual and Worker-Related Factors on Employee Attitudes

A raw and standardised regression analysis was performed to ascertain if site, age, gender, marital status, level of education, religion, employment status, working experience, job category, and training status predict the employee attitudes toward respiratory protection. The results are shown in Table 4.20. As delineated in Table 4.20, the work site (*p*=0.000) and the level of education (*p*=0.000) significantly contributed to employees' attitudes aligned to respiratory protection.

Table 4.20: Raw and standardised regression of individual and worker-related factors on employee attitudes

	Unstandardised Coefficients		**Standardised Coefficients**			**95% Confidence Interval for B**	
	B	Std. Error	Beta	**t**	**Sig.**	Lower Bound	Upper Bound
(Constant)	1.063	0.132		8.068	0.000	0.803	1.322
Site	0.159	0.007	0.824	21.654	0.000	0.144	0.173
Age	-0.025	0.020	-0.042	-1.259	0.209	-0.065	0.014
Gender	0.041	0.033	0.036	1.245	0.214	-0.024	0.107
Marital status	-0.093	0.047	-0.059	-1.987	0.048	-0.186	-0.001
Level of education	-0.109	0.020	-0.167	-5.511	0.000	-0.148	-0.070
Religion	0.024	0.042	0.017	0.573	0.567	-0.058	0.106
Employment status	0.016	0.053	0.009	0.300	0.764	-0.089	0.121
Working experience	0.021	0.018	0.039	1.166	0.244	-0.015	0.058
Job category	-0.006	0.005	-0.048	-1.342	0.180	-0.015	0.003
Training status	0.030	0.030	0.028	0.981	0.327	-0.030	0.090

Dependent variable: Attitudes

4.4.4 Multiple Regression Analysis of Factors Influencing Employee Practices

Individual and work-related factors were subjected to standard regression analysis to predict employee practices on respiratory protection. Table 4.21 shows the multiple regression model summary.

Table 4.21: Model summary of multiple regression analysis of factors influencing employee practices

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
					F Change	df1	df2	
.835[a]	0.698	0.687	0.257	0.698	67.626	10	293	0.000

Predictors: (Constant), site, age, gender, marital status, level of education, religion, employment status, working experience, job category, training status.

The prediction model summary was statistically significant, F (10, 293) = 67.626, p=0.000, and accounted for approximately 69% of the variance of individual and work-related factors on employee practices (R^2 = 0.698, Adjusted R^2 = 0.687). A high degree of correlation was denoted (R=0.835). Hence, individual and work-related factors highly predict employee respiratory protection practices.

4.4.4.1 Raw and Standardised Regression of Individual and Worker-Related Factors on Employee Practice

A raw and standardised regression analysis was performed to ascertain if site, age, gender, marital status, level of education, religion, employment status, working experience, job category, and training status predict the employee's practice on respiratory protection. The results are shown in Table 4.22.

Table 4.22: Raw and standardised regression of individual and worker-related factors on employee practice

	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.063	0.132		8.068	0.000	0.803	1.322
Site	0.159	0.007	0.824	21.654	0.244	-0.015	0.058
Age	-0.025	0.020	-0.042	-1.259	0.209	-0.065	0.014
Gender	0.041	0.033	0.036	1.245	0.214	-0.024	0.107
Marital status	-0.093	0.047	-0.059	-1.987	0.048	-0.186	-0.001
Level of education	-0.109	0.020	-0.167	-5.511	0.000	-0.148	-0.070
Religion	0.024	0.042	0.017	0.573	0.567	-0.058	0.106
Employment status	0.016	0.053	0.009	0.300	0.764	-0.089	0.121
Working experience	0.021	0.018	0.039	1.166	0.000	-0.144	0.173
Job category	-0.006	0.005	-0.048	-1.342	0.180	-0.015	0.003
Training status	0.030	0.030	0.028	0.981	0.001	-0.030	0.090

Dependent variable: Practices

Employee practices were significantly predicted by the level of education (p=0.000), working experience (p=0.000), and training status (p=0.001).

4.5 Qualitative Results on Quarry and Allied Workers' Knowledge, Attitudes, and Practices (KAP)

This section outlines results on knowledge, attitudes, and practices (KAP) of quarry and allied workers on occupational respiratory protection based on interviews with 11 managerial staff from nine sites.

4.5.1 Thematic Presentation of Findings

An inductive way of analysing data (coding and theme are guided by the data content) was used. The data was then presented in themes, including transcribed quotes from the respondents to reinforce the results.

Table 4.23: Themes and sub-themes summary

Theme	Subthemes
1. Employee knowledge of respiratory protection	1.1 Poor understanding of respiratory protection 1.2 Irregular awareness/ training on respiratory protection
2. Employee attitudes aligned with respiratory protection	2.1 Negative attitudes on respiratory protection 2.2 Positive attitudes on respiratory protection
3. Employee practices on respiratory protection	3.1 Inconsistent use of Respiratory Protective Equipment (RPE) 3.2 Improper usability of RPE 3.3 Incorrect donning and doffing of RPE

Table 4.23 summarises the themes and sub-themes on quarry and allied workers' knowledge, attitudes, and practices (KPA) on occupational respiratory protection. Quotes from the participants combined will be presented below, with individual themes following a sub-theme(s).

4.5.1.1 Theme 1: Employee Knowledge of Respiratory Protection

To facilitate the elaboration of outcomes of Theme 1, employees' knowledge of respiratory protection, the subthemes are presented as follows.

4.5.1.1.1 Theme 1.1: Poor Understanding of Respiratory Protection

The interview participants described the lack of sufficient education, with limited abilities for reasoning, as prominent amongst quarry and allied workers. This is because most of the quarry and allied workers have only completed secondary education without a pass. This is a contributing factor to the lack of knowledge of respiratory protection education. **Participant 3** revealed that "*Most of our employees here attained education up to the secondary level, but they did not pass. So, you would find that their level of understanding of dust protection is very limited.*" In addition, the study also revealed that the level of secondary education often leads to a lack of understanding of health and safety instructions. Interviewed participants showed concerns about the limited understanding of the respiratory protection concept among quarry and allied workers. **Participant 4** intimated that "*Understanding of respiration protection among the workers is low. Their (workers) reasoning abilities are so low*". Literature reviewed in chapter two noted that education is a precursor for knowledge that solidifies physical and intellectual abilities, fosters the growth of moral attributes, and demonstrates appropriate behaviour and manners (Ashley & O'Connor, 2017). Arstad and Aven (2017) mention that employees' knowledge of respiratory protection involves wearing masks, limiting dust exposure periods, and complying with respiratory guidelines. Thus, workers need to be educated on the proper usage of masks, which may prevent the worsening of pulmonary function due to dust exposure. This literature was supported by table 4.14 that indicate that the majority of the workers, 66.8% (n=203), had inadequate knowledge of respiratory protection and Table 4.16 shows that there is a very high positive correlation between knowledge and practice (r=0.934), between knowledge and practice (r=0.816), as well as a high positive association between practice and attitudes (r=0.762). The quantitative findings are supported by **Participant 7,** who indicated, "*Most people working here do not fully understand and appreciate it (respiratory protection). Respiratory protection is a bit complex to understand".* These findings imply that inadequate knowledge of respiratory protection is highly impacted by the lack of education and low literacy levels amongst quarry and allied workers.

4.5.1.1.2 Theme 1.2: Irregular Awareness/Training on Respiratory Protection

The following findings are aligned with the level of awareness/training as it influences the employees' level of knowledge on respiratory protection. The study revealed that most training in quarry mines for allied and quarry workers is not consistent and is only offered to new employees. These irregular trainings for new employees demonstrate irregular employees' awareness/training on respiratory protection, as revealed by **Participant 2** revealed that "*Our training is sporadic, as very few new workers are formally trained, which then creates a knowledge gap regarding respiratory protection.".* According to NOISH (2019), training programmes strengthen employee skills and enhance knowledge and attitude. Kumar, Gupta, Agarwal, and Singh (2016) discovered that trained workers concerning specific tasks and respiratory protection were largely responsible for their occupational well-being. **Participant 9** mentioned that "*Awareness imparts knowledge to the employees; however, respiratory protection awareness has not been consistent, so you would find that workers are not very knowledgeable*". This statement is supported by literature that states that the mandatory respiratory training programmes for employees susceptible to respirable dust exposure assist in deterring respiratory symptoms and conditions among the workers (Dhatrak & Nandi, 2019). Table 4.18 also indicates that training status (p=0.000) bears statistical significance in predicting the level of employee knowledge on respiratory protection. Premised on the participants' quotes, the lack of or irregular training on respiratory protection has widened the knowledge gap between quarry and allied workers on respiratory protection.

4.5.1.2 Theme 2: Employee Attitudes Aligned to Respiratory Protection

Attitudes impact how respiratory protective devices are used to prevent inhalation of respirable dust. The participants had mixed moods of positive and negative attitudes regarding respiratory protection. Employee attitudes aligned to respiratory protection emerged from the data analysis and were subsequently grouped into two sub-themes.

4.5.1.2.1 Theme 2.1: Positive Attitudes to Respiratory Protection

The study findings revealed that some experienced quarry and allied workers had a positive attitude towards respiratory protection and believed that respiratory protection helps in prolonging life and helps in preventing respiratory illness. Positive attitudes refer to the workers' favourable thinking and general feelings towards respiratory protection. The study participants reflected positive employee attitudes aligned with respiratory protection, as supported by **participant 1,** who alluded that "*most experienced feel that respiratory protection enables them to live longer as they do not have to inhale harmful dust*". In addition, **Participant 5** remarked that "*our workers now value the use of respiratory protection equipment because they now think it helps them from getting sick from dust, which they work with daily*". The noted quote from participants is supported by literature that states that positive attitudes among employees are linked to a higher likelihood of exercising caution while handling risks or illnesses (Vacek et al., 2019). Furthermore, it is believed that attitudes shift due to employees learning about potential risks at work and having the chance to be sensitive to dust-prone work situations. Workers' exposure to respirable dust is favourably reduced when the employees have positive attitudes toward respiratory protection programs (Antao & Pinheiro, 2015). These findings show that quarry and allied workers positively acknowledge respiratory protection as key to aiding their occupational health. As also shown in Table 4.15, all workers with positive attitudes are predicted to exhibit protection behaviour.

4.5.1.2.2 Theme 2.2: Negative Attitudes to Respiratory Protection

Negative attitudes refer to the workers' unfavourable way of thinking and general feelings toward respiratory protection. Data collected from the participants portrayed that some employees had negative attitudes toward respiratory protection, as indicated by the following quotes. Participant **5** mentioned that: "*looking at our current situation, most workers do not see or think quarry dust is harmful; hence, they are not inclined to use respiratory protection*". In addition, **Participant 8** stated that, "*Some people are more concerned that using masks and respirators (respiratory protection) make* *them unable to carry out their duties than being protected effectively*". These quotes are supported by literature and quantitative findings of the study. Research states that employee attitudes toward respiratory protection are a psychological tendency of employees based on evaluative assessments of changes, both positive and negative assessments (Vacek et al., 2019). Table 4.20 shows that quarry and allied workers with negative attitudes (57.3%) portray negative or bad respiratory practices (82.1%). Furthermore, the study also revealed that it is addressing negative attitudes and fostering protective behaviour is vital. **Participant 9** revealed that: "*To other employees, respiratory protection equipment brings difficulty in breathing and makes it difficult for face recognition*". **Participant 10** reiterated that: "*Concerns about discomfort have been noted from the employees, thus deterring effective respiratory protection*". As demonstrated by managerial staff outcomes, negative attitudes are linked to the use of respiratory protection. That is when quarry and allied workers feel and think that respirable dust is not harmful. In a way, workers do not recognise the importance of the need to protect themselves and others. The link between negative attitudes and respiratory protection includes a lack of fear about illness associated with respiratory protection, discomfort from respiratory protection equipment use, and inefficiency**.**

4.5.1.3 Theme 3: Employee Practices on Respiratory Protection

Employee practice refers to the actions of quarry and allied workers relating to respiratory protection. The employees' actions regarding respiratory protection were seen as good and bad practices. Data collected from interviews revealed that bad practices were noted through inconsistent use of RPE, non-compliance with respiratory protection requirements, and incorrect donning and doffing of RPE. The following section will discuss subthemes on employee practices regarding respiratory protection.

4.5.1.3.1 Theme 3.1: Inconsistent Use of RPE

The study revealed that there was a frequent non-use of RPE, which led to the exposure of quarry and allied workers to dust particles and health risks. Most of the exposed individuals were also aware that breathing difficulties may emerge from prolonged or frequent exposure to coal dust and knew how to protect themselves from dust exposure (Mavhunga, 2018). The study findings showed that most quarry and allied workers only used RPE when supervised or upon request. As depicted by data collected through interviews, most employees have not been consistently using RPE, as indicated in some responses below. **Participant 1** revealed that: "*Certain workers, if not most, always wear their respiratory protection equipment at work*". In addition, **Participant 6** echoed that: "*There has been irregular use of respiratory protection equipment by employees*". Table 4.14 showed that 69% of quarry and allied workers had poor practices in the use of RPE. This data was supported by **Participant 9**, who resonated that: "*One of our challenges is workers not wanting to put on their protective devices always or when required".* The above quotes indicate that most employees inconsistently use RPE.

This is a bad practice as the employees are exposed to harmful dust, which adversely affects their health.

4.5.1.3.2 Theme 3.2: Improper Usability of RPE

The usability of respiratory protective devices impacts proper use and, thereby, the effectiveness of devices for their intended use. Findings obtained from the managerial staff elicited that some employees do not or partially comply with respiratory protection requirements, as indicated by the following sentiments. **Participant 4** alluded that: "*While using respiratory protection, some people pull the device away from the mouth to communicate; others store the device in an unsafe manner."* In addition, **Participant 5** indicated that: *"There is an incorrect wearing of PPE, such as wrong placement of masks and respirators exposing the nose or mouth*". These quotes are supported by literature that states that the key factor in the usage of PPE is correctly selecting an RPE following a given pollutant(s) and its proper wearing, which is crucial in ensuring effective protection (Ashley & O'Connor, 2017). Yarpuz-Bozdogan (2018) found out that some quarry workers chose not to wear PPE for multiple reasons, which include uncomfortable PPE, inconvenience, interference with work, undesirable personal appearance, and because of meteorological factors such as hot weather conditions. The study also revealed that quarry and allied workers demonstrate poor usage and noncompliance with the use of PPE. **Participant 10** highlighted that: "*Some workers use their masks or respirators while having beards, which limits protection from dust inhalation*". The study findings demonstrate the bad actions of employees not complying with the use of respiratory protection devices. This implies that the quarry and allied workers are not correctly using RPE, which deters respiratory protection efficiency.

4.5.1.3.3 Theme 3.3: Incorrect Donning and Doffing of RPE

The study findings described how improper donning and doffing practices were common and caused exposure during equipment handling. Workers often put on and remove RPE incorrectly, risking contamination. Donning and doffing of RPE is an essential practice in respiratory protection. Data collected from the mine managers showed that most quarry and allied workers could not correctly don and doff RPE, as shown by the following quotes. **Participant 3** specified that "*commonly noted is the improper donning and doffing of respiratory protective devices".* In addition, **Participant 5** indicated that "*The wearing and removal of respiratory protection equipment proves problematic to our employees* ". The study quotes are supported by literature that states that donning and doffing errors taken by businesses to reduce risks at the workplace contribute to a high level of respiratory exposure incidents (Burton, 2010). Therefore, quarry mines need to eliminate donning and doffing errors as these errors are a cause of contamination (Jiang & Luo, 2021). Table 4.22 int he study supports these statement and quotes as it shows how correct practices are significantly influenced by knowledge, attitude and experience thus, emphasising the needs for trainings in the proper use of RPE handling as also **Participant 6** mentioned that "*The correct way of putting on and off respiratory protection (equipment) poses particular challenges to some employees as they proved not to be acquainted with such*". Premised on the above participant quotes, a harmful practice that involves improper donning and doffing of RPE was noted among quarry and allied workers. This implies that employees contain themselves and others because they are not properly wearing and removing their RPE as required.

4.6 Particle Filtration Efficacy Results

A particle filtration efficacy (PFE) laboratory experiment was carried out on the filters/masks, and the following results were revealed:

4.6.1 Pre- and Post-Gravimetric Weighing

Table 4.24 exhibits the mask filter results for pre- and post-weighing. Filters were weighed before and after use to evaluate the amount of dust trapped in them. No weight adjustment factor was used during this weighing. The mask filter for Site C (row 5) shows a negative net dust amount, which can be attributed to ambient conditions in the weighing room. The mask filters collected relatively little dust, which was negligible compared to the dust that passed through them. The net dust quantities displayed in Table 4.24 thus indicate that no significant amount of dust particles passed through these mask filters remained trapped inside the filters.

Table 4.24: Gravimetric results

Sample	Description	Pre-Weight (g)	Post weight (g	Post Difference (g)
Site A	PIONEER SAFETY EP005 EN ISO 9001:2008 EN149:2001 FFP2 CE0194	8.159	8.163	0.004
Site B	PIONEER SAFETY EP005 EN ISO 9001:2008 EN149:2001 FFP2 CE0194	7.818	7.823	0.005
Site C	WURTH 0899 1211 102 CE 2849 EN149:2001+A1:2009 FFP2 NR	11.748	11.742	-0.006
Site D	WURTH 0899 1211 102 2849 EN149:2001+A1:2009 FFP2 NR	10.281	10.284	0.003
Site E	QSA 2010 FFP1 NR A2/2006/21	7.227	7.283	0.056
Site F	QSA 2010 FFP1 NR A2/2006/21	6.935	6.941	0.006
Site G	QSA 2010 FFP1 NR A2/2006/21	6.880	6.891	0.011

4.6.2 Mask Testing Results

Table 4.25 shows the weighing results following the appropriate sample times of 1 and 5 minutes. Column 2 shows the weight of the filters after 1-minute sampling. The results demonstrate that when the masks were exposed for a brief period, very little dust passed through them. Sample Site G had the highest exposure to dust at 0.015mg, above the technique's standard uncertainty of ±0.010mg. The mass on filters increased significantly with a 5-minute sample period; Sites A and B had lower filtered dust weights, whereas Sites C, D, F, and G had higher values. The latter once again produced much dust.

Table 4.25: Gravimetric results

Sample ID	Description	Weight 1 Minute (mg)	Weight 5 Minutes (mg)
Site A	PIONEER SAFETY EP005 EN ISO 9001:2008 EN149:2001 FFP2 CE0194	0.000	0.017
Site B	PIONEER SAFETY EP005 EN ISO 9001:2008 EN149:2001 FFP2 CE0194	0.008	0.038
Site C	WURTH 0899 1211 102 CE 2849 EN149:2001+A1:2009 FFP2 NR	0.000	0.290
Site D	WURTH 0899 1211 102 2849 EN149:2001+A1:2009 FFP2 NR	0.002	0.218
Site E	QSA 2010 FFP1 NR A2/2006/21	0.005	0.057
Site F	QSA 2010 FFP1 NR A2/2006/21	0.007	0.368
Site G	QSA 2010 FFP1 NR A2/2006/21	0.015	0.437

4.6.3 Particle Size Analysis

A particle size analyser approach was utilised to determine the size of dust particles filtered through the masks. They were dispersed in a mixture of water and isopropanol to remove dust from the filters. The laser light scattering particle size analyser approach employs the principle that a beam of light is passed through the sample mixture containing the dispersion of particles. Some light is scattered as the beam passes, while some is absorbed. The transmitted beam, focused on the detector, is collected and processed for calculation. This was the case with the sample particles investigated in this process. Median values are defined as values where half the population resides above this point and half below, whereas PM 10 represents the percentage of small particles below 10µm. These are the particles that are inhalable and can penetrate the lungs. From Table 4.26 below, all samples showed that smaller particles could filter through the masks with a median size below 10µm. Sites A, B, and C showed smaller particles with PM_{10} of 100%; sample Site D showed the largest particle size, with at least 60% below the PM10 range.

Table 4.26: Particle Size Analyser Results

Sample ID	Description	Median (ug)	PM10
Site A	PIONEER SAFETY EP005 EN ISO 9001:2008	2.572	99%
Site B	EN149:2001 FFP2 CE0194	2.423	100%
Site C	PIONEER SAFETY EP005 EN ISO 9001:2008	4.596	86%
Site D	EN149:2001 FFP2 CE0194	7.006	60%
Site E	WURTH 0899 1211 102 CE 2849	3.172	100%
Site F	EN149:2001+A1:2009 FFP2 NR	5.281	64%
Site G	WURTH 0899 1211 102 2849	3.821	82%

4.7 Namibian Legal Provisions Protecting Quarry and Allied Workers from Respiratory Infections

Regarding protecting quarry and allied workers from respiratory infections in Namibia, OHS is governed by the 'Labour Act' (Labour Act 2007: Regulations relating to the Health and Safety of Employees at Work). The table below gives an overview of the key points in the Labour Act 6 of 2007 that are aligned with protecting quarry and allied workers from respiratory infections.

Table 4.27: Overview of the Labour Act 6 of 2007 aligned to the protection of quarry and allied workers from respiratory infections

Legislation	OEL for crystalline silica dust	Regulations on dust control and monitoring in the workplace	Prescription of dust measurement methods
Labour Act 6 of 2007: Regulations relating to the health and safety of employees at work.	Crystalline silica 0,05 mg/m3 Silica quartz 0,1 mg/m3	General: Employer to take adequate measures for hazard exposure measurements, systematic data recording, and reporting to the Chief Medical Officer of Occupational Health in case of exposure above the limit. Specific silica regulation: Prescribes preventive measures in terms of ventilation, wetting systems, and PPE provision.	None

4.7.1 Responsibility of Employer on Employee Health and Safety

Legislations governing OSH Chapter 4 of the Labour Act, 2007 (Act No. 11 of 2007) and Regulations Relating to the Health and Safety of Employees at Work, made under the Labour Act, 2007 (Act No. 6 of 2007) places a legal duty upon employers to provide a healthy and safe working environment for the workers and any other person who might be affected by their operations. In the Labour Act of 2007, it has been expressly stated that employers should ensure a safe working environment with less risk to the health of employees, and the establishment must have adequate facilities and arrangements for the welfare of employees. The machinery is to be maintained without any risk to the employees. Employees are to be given protective clothing where necessary. Under the Regulations relating to the Health and Safety of Employees at Work, all safety equipment and facilities must be supplied free of charge, including personal protective equipment and clothing.

4.7.2 Airborne Hazardous Substances Exposure Limits

The 'Labour Act' [Schedule 1(2)] prescribes fixed exposure limits for airborne hazardous substances and more detailed silica regulations [Schedule 2(3)]. There are, however, no guidelines or protocols on how dust monitoring and measurements should be conducted (spot sampling versus gravimetric sampling, specifications for the related equipment, etc.).

4.7.3 Reporting of Occupational Injuries and Diseases

The Namibian Labour Act sets out the responsibility of the employer to report occupational injuries and diseases, including respiratory conditions. A systematic reporting of occupational lung diseases to the Chief Medical Officer is noted as not taking place, as shown in Table 4.28 below.

Table 4.28: Overview of the status of reporting occupational lung diseases and conditions

Recording/reporting criteria	Status
Reporting of occupational diseases per legislation	Yes
Actual statistics on occupational lung diseases	No current information
Record keeping of personal lifetime exposures	Yes

4.7.4 Legislative Enforcement for OHS in the Mining Sector

Legislation protects mineworkers from dust-related occupational lung diseases, with enforcement of these regulations being done by Labour inspectors under the Ministry of Labour and Social Welfare. Labour inspectors generally oversee the application of these regulations. Particular occupational health regulations are overseen by the 'Chief Medical Officer of Occupational Health and Safety' acting under the Ministry of Health and Social Services.

4.7.5 Occupational Health Screening

The Namibian Labour Act provides occupational health screening in medical facilities on mining sites or contracted out to occupational health service providers by mining houses. The law on occupational health screening stipulates that employees should undergo pre-employment and periodic health checks during employment. Registered occupational medical practitioners are supposed to carry out pre-employment and periodic medical examinations based on that risk profile. Currently, the Ministry of Health has registered a total of 26 occupational medical practitioners across the country (Dec 2016).

Table 4.29: Legal provisions on occupational health screening within the mining industry

Provisions for occupational health screening by the Labour Act of 2007	Status
Fitness for work/ pre-employment examinations	Yes
Periodic OH examinations	Yes
Exit examinations	No
Systematic periodic examinations of ex-mineworkers	No

4.7.6 Social Protection of Diseased Employees

Compensation is paid for temporary disablement, permanent disablement, and death. Medical expenses deemed within reason are payable within 2 years or longer if required. Compensation for employment-related injuries and diseases is the most widespread form of social protection. The Namibian law on occupational protection establishes compensation systems based on employer liability or integrated social protection schemes. The Namibian Employee Compensation Act, 1941 (amended 1995) provides employee compensation insurance on a collective liability basis and is administered by the Social Security Commission. The Commission is the Trustee of the Accident Fund. All compensation benefit costs, as well as the costs of administration of the Act, are paid from the Accident Fund, and the Commission determines all claims and decides on all matters falling within the scope of the Act. This implies that the employee is compensated in the event of occupational injury or the development of any occupational condition, such as pneumoconiosis.

Table 4.30: Social compensation schemes in Namibia

Legislation	Social protection schemes	Coverage of respiratory diseases and conditions
Employee Compensation Amendment Act of 1995	**Social insurance scheme:** Employees' compensation insurance, administered by the Social Security Commission, is a trustee of the Accident Fund. Under the Act, every employer must register and pay annual assessments to the Accident Fund.	Pneumoconiosis, silico tuberculosis, TB, when silicosis is essential for contracting TB

4.7.7 Regional Harmonisation of Legislative Frameworks

The SADC "Protocol on Mining supports member states in formulating policies and creating a regulatory and administrative environment leading to the development of their mineral resources sector. The plan contains eight harmonisation themes, of which theme four targets safety, health, and environmental concerns in the mining sector. ILO Conventions C155, C159, C161, R`71, C176, C187, C17, and C18, highlighted in Article 12 of the Charter of Fundamental Rights in SADC, have not been ratified in Namibia. The level of ratification of international labour conventions is very low in Namibia. The ratification status of ILO conventions suggests little harmonisation in the field of labour laws. However, the review of actual legislative frameworks in Namibia shows that many principles and recommendations contained in the above conventions have been incorporated into the national legislation.

Table 4.31: Ratification of ILO Conventions and Recommendations

International labour conventions	Ratification status
Convention No. 155	Not ratified
Convention No. 159	Not ratified
Convention No. 161	Not ratified
Recommendation No. 171	Not ratified
Convention No. 176	Not ratified
Convention No. 187	Not ratified
Convention No. 17	Not ratified
Convention No. 18	Not ratified

4.8 Chapter Summary

This chapter presented the outcome of the study in terms of the phases. The first section presents the socio-demographic data of the participants. The current practices in protecting quarry and allied workers from respiratory infections, KPA of quarry and allied workers on occupational respiratory protection, the particle filtration efficiency of the masks/filters, and a review of the Namibian legal provisions protecting quarry and allied workers from respiratory infections. The next chapter discusses the study results.

CHAPTER 5: DISCUSSION OF RESULTS

5.0 Introduction

The study aimed to develop a framework for the protection of quarry and allied workers from occupational respiratory infection in Namibia. Therefore, this chapter will discuss the findings of the study following the assessed research objectives as outlined below.

5.1 Assessment of the Current Practices in Protecting Quarry and Allied Workers from Respiratory Infections

This study revealed the inability of quarry mines and construction employers to apply feasible respirable dust engineering controls in the form of water mists and sprays. These findings entail that Namibian quarry, and allied workers have no engineering controls to reduce their exposure to respirable dust. Conflicting with the current findings are Gürcanl, Baradan, and Uzun (2015), who argue that engineering controls remove or reduce respirable dust hazards at the source by means of suppressing, diluting, or diverting dust generated by mining, construction, and associated activities. The NIOSH (2019) adds that without wetting techniques such as water sprays or mists, quarry and allied workers are subjected to an increase of respirable dust emissions by up to 96%, giving rise to up to 20 times more respirable dust concentration than usual. Such high respirable dust concentrations are responsible for the development of respiratory symptoms and conditions, as attributed by Zhang et al. (2016). The failure to institute feasible engineering controls (specifically wetting techniques) by quarry mines and construction employers can be attributed to a lack of reliable water supply and capital costs in setting up the controls. Seaman et al. (2020) complement that capital costs of setting up engineering controls tend to be higher, mostly out of reach for quarry miners and entrepreneurial construction companies.

The present study highlights the lack of educational/training programmes among Namibian quarry and allied workers. With insufficient educational/training programmes, employees develop knowledge gaps on respiratory protection, making it difficult to cooperate and actively participate in the respiratory protection program (Zin & Ismail, 2015). Alemu et al. (2020) note that the lack of training diminishes employee attention to proper respirator use and may result in a long period of poor respirator practice before problems are identified and corrected. In contrast, Ye et al. (2013) discovered that educational training programs based on safety precautions and PPE use decreased lung diseases linked to dust exposure. Similarly, Hicham et al. (2017) in Australia, Wisconsin, found that PPE use among quarry workers significantly increased following a 6-month educational programme intervention. Premised on the findings. Additionally, Dolinar (2018) provided education/training on lung health protection for Nigerian construction workers, and 18.8% of study participants wore a respirator all the time 3 months post-intervention, which was improved from 6.3% of individuals who wore a respirator all the time pre-intervention. The act of training entails that Namibian quarry, and allied workers are more inclined to occupational-related lung disease risks and negative attitudes, inadequate knowledge, and harmful practices regarding respiratory protection equipment. Educational and training programmes on safety precautions and behaviours, especially proper use of PPE, have been shown to be effective methods to increase knowledge and prevent respiratory symptoms and diseases related to the quarry, construction, and allied exposures (Jacobsen et al., 2021).

The current study showed that all the quarry and allied workers did not undergo a mandatory initial medical examination. This study's findings contradict NIOSH (2019), which argues that mining and construction enterprises should provide each new employee with initial medical examinations. According to Lancet (2019), an initial mandatory medical examination assesses a new employee's baseline pulmonary status. NIOSH (2019) adds that initial examination assists in the early detection of respirable dust-related illnesses and conditions that make employees more susceptible to the toxic effects of respirable dust. Thus, Namibian quarry and allied workers are least protected from respiratory conditions without initial examination, heightening the risk of becoming impaired without early detection. Lancet (2019) illustrates that without initial examination, early detection and intervention of respiratory illness are slowed, allowing greater disease progression and thereby deteriorating health outcomes. Also pointed out in the findings is the inability of most quarry and allied workers to undergo periodic medical examinations. Almberg et al. (2020) maintain that periodic examinations allow for comparing an employee's prior examination results. Deprived of an individual medical baseline (initial medical examinations), valuable in assessing any future health changes and comparable point (periodic examination), the protection of quarry and allied workers from respirable dust-related illnesses is minimal.

Furthermore, employees must be evaluated medically to be sure about their ability to use a respirator because using a respirator may create a psychological burden on employees, depending on the type of respirator, the type of job, and the workplace conditions in which the respirator is used.

In the present study, most quarry and allied workers were not provided with PPE/C despite it being a mandatory obligation enshrined in the Namibian Labour Act. Without PPE/C, protection from respiratory conditions is jeopardised. Concurring with the current study findings, Coffman et al. (2021) evaluated respirator use in the USA They identified shortcomings in RPEs that could be attributed to employer unfamiliarity with regulatory requirements or the possibility that employers were not allocating the necessary resources to implement respiratory protection guidelines. Of the industries surveyed by Coffman et al. (2021), 66% did not have respiratory protection protocols for deciding how respirators are used. This is the same fate suffered by Namibian quarry and allied workers of their employers, who failed to adhere to respiratory protection protocols and could not avail themselves of appropriate resources for respiratory protection programmes. The study noted that most of those provided with PPE/C were given free of charge. These findings are in line with Alemu, Yitayew et al. (2020), who reported that respirators that are approved by NIOSH and suitable for their intended purpose must be provided by employers at no cost to mine and construction workers to protect themselves from respirable dust effectively. Workers are being given respirators for free at work to lessen their susceptibility to respirable dust.

The use of PPE/C among quarry and allied workers was inconsistent, as most individuals occasionally used PPE/C. These findings imply that Namibian quarry and allied workers lack adherence to PPE/C; hence, they become susceptible to developing respiratory conditions and related illnesses. Dhatrak and Nandi (2019) discovered that compliance with respiratory protection guidelines in many industries is troublingly low, especially among workers in construction and mining. Conversely, Bozdogan (2018) noted that using PPE decreased the intermediate risk of respiratory injury by 44%, the maximum risk by 32%, and increased the chances of no risk of respiratory effects by 24%. Aligned with these study findings are Casey and Mazurek (2021), who found a low compliance of 35.7% to wearing respirators in the 2020 Respiratory Safety Survey conducted in developing countries among construction workers. Quarry workers were more likely to wear respirators than construction workers 39.1% and 32.5%, respectively), and charcoal workers were 3.5 times less likely to wear respiratory protection than any other category (Casey & Mazurek, 2021).

Bozdogan (2018) attributes the failure to use PPE/C by most quarry workers to multiple reasons, which include uncomfortable PPE, inconvenience, interference with work, and hot weather conditions. The use of N95 by quarry workers or any other worker is hampered by relevant issues such as the difficulty in forming and maintaining an airtight seal that diminishes fit against the face (Bergman et al., 2015). Additionally, factors associated with the perception of discomfort while worn, such as heat caused by exhaled breath, tightness against the face, and the additional effort required to breathe through the filter media layers of an N95, were also raised (Shaffer & Janssen, 2015). Discomfort is the most typical reason Guerin and Toland (2020) cite for improper use of a respirator. Typical forms of discomfort encompass facial pressure, heat, pain, laboured movement of facial muscles, or skin itchiness. On the other hand, Kearney et al. (2015) found out that construction and quarry workers who wear PPE regularly do so to avoid injury (70%), family telling them to wear PPE (38%), ease of using PPE (36%), and low cost of equipment (22%). Better control of safety behaviours, such as wearing PPE, is critical for lowering the risk of mining and construction-related respiratory symptoms and diseases.

Premised on the current study findings, the type of PPE/C given to Namibian quarry and allied workers is biased towards protecting the general body (overalls) rather than the respiratory system, which is the priority given the nature of their work. With very few employees using respirators, the degree of protection becomes low, thereby increasing the risk of respiratory adverse health effects associated with exposure to respirable dust. Contrary to the current study findings, NIOSH (2019) recommends using respirators as an interim measure in maintaining worker exposure to respirable dust at or below the proposed PEL. Ashley and O'Connor (2017) mention that without respirators in mining and construction environments, there is a greater chance that an employee will inhale potentially dangerous air contaminants. Ashley and O’Connor (2017) add that without respiratory protection, employees working under respirable dust exposure lack the expected level of protection, which increases the possibility of overexposure to a harmful air contaminant.

Evidence from the current study revealed the use of disposable N95 and surgical masks against respirable dust exposure. Ashley and O'Connor (2017) contend that respirators have different levels of protection and are used in various conditions; hence, it is important to understand which respirator will protect against specified dust PEL exposures. According to Lee et al. (2010), disposable N95 respirators protect against larger dust particles, of which quarry mines and construction sites can generate smaller and finer particles. Conversely, half-facepiece respirators protect from smaller particles of dust, and full-facepiece respirators provide eye and respiratory protection. On the other hand, Sapbamrer et al. (2021) found that surgical masks are the least protective, with a filtration efficiency between 25.7-61.5%, and half-facepiece P100 respirators were the most protective, with 96.5-98.9% filtration efficiency. Therefore, the continued dust exposure by the quarry and allied workers emphasises the importance of filtering facepiece respirators (FFRs) in dusty environments (Lee, Yermakov, & Grinshpun, 2010).

The findings showed that of the employees supplied with respirators, none obtained respirator fit testing. In the total absence of respirator fit testing, it is axiomatic that quarry and allied works in Namibia are not adequately protected against breathing respirable dust and contaminated ambient air. Studies show that a lack of fit testing results in reduced protection. Aligned with the current study findings are NOISH (2019), who found that workers using disposable respirators were not getting adequate protection because the respirators had not been fit-tested. NOISH (2021) urges that workers who use respirators without fit testing, similar to the findings of the current study, suffer adverse health effects resulting from overexposure to airborne contaminants. As alluded to by OSHA (2016), The quarry and allied workers in Namibia use poorly fitting facepieces, exposing them to respirable dust without test fitting. Also, with poorly fitting respirators, discomfort is bound, resulting in poor adherence to wearing respirators. Jiang and Luo (2021) add that proper fit testing is necessary to minimise discomfort and ensure that the respirator selected offers sufficient protection.

As revealed by the study findings, less than half of the quarry and allied workers were not adequately protected by respirators due to excessive facial hair. Hyatt and Pritchard (2012) showed that facial hair can have a range of effects on respirator performance, depending on factors such as the degree to which the hair interferes with the sealing surface of the respirator and the physical characteristics of the hair. Generally, the presence of beards and wide sideburns had a detrimental effect on the performance of the respirators. This means that Namibian quarry and allied workers with excessive facial hair, including stubble and wide sideburns, that interfere with the seal cannot expect to obtain as high a degree of respirator performance as clean-shaven individuals (NOISH, 2021). Skretvedt and Loschiavo (2013) tested half-mask and full-facepiece respirators on 370 male employees who were fit-tested qualitatively and quantitatively; bearded workers consistently failed qualitative fit testing. However, a study by Fergin (2011) found no significant difference in respirator performance for employees with or without beards. This means that facial hair does not influence respirator fitting effectiveness. Contrarily, Rengasamy et al. (2017) contend that tight-fitting facepieces are not to be worn by employees with any condition (beard or sideburn) that interferes with the face-to-facepiece seal or valve function.

Premised on the regression model, the level of education, age, working experience, and worksite risk perception predict or influence how quarry and allied workers are protected from respiratory infections and conditions.

From the current study findings, the educational level of quarry and allied workers greatly influenced respiratory protection. Lower educational levels of primary level and below, as noted among most Namibian quarry and allied workers, entail lower respiratory protection, as some of the employees might fail to comprehend and apply respiratory protection information. The current study findings align with NOISH (2019), who found that the respondents' level of education significantly affected respiratory protection, particularly when comparing respondents with and without formal education. Furthermore, Rengasamy et al. (2017) exhibited that people who did not complete formal education also did not protect themselves from respiratory hazards as they shunned the proper PPE at work. In Zambia, construction workers with no education had the least proportion reporting the use of PPE, training on respiratory protection, and use of engineering controls compared to those with primary and secondary education (Z’gambo, 2015).

Age has been demonstrated to be a major contributor to Namibian quarry and allied workers. A similar study by Kumar, Gupta, Agarwal, and Singh (2016) on respirator usage showed that older workers were more likely to wear PPE than their younger counterparts. Older workers attributed this phenomenon to younger workers' lack of experience and feelings of invincibility. Younger workers suggested that they had not yet formed a habit of using PPE or did not realise its importance for specific tasks. Thus, younger workers are less protected than older workers; hence, more respiratory symptoms and complaints are bound to come from younger workers. Contrarily, the age variable and use of PPE were low among older employees. This was attributed to older workers not having had a chance to be trained on the importance of PPE. Additionally, Barnes, Goh, Leong, and Hoy (2019) argue that older workers dismissed training and information from younger workers who were new to the workplace.

Employee working experience proved to be an influencer on the use of PPE among quarry and allied workers. These findings aligned with Beth's (2018) study, which reported a relationship between years of experience and the use of PPEs, whereby the higher number of years of working experience showed improved utilisation of PPEs while working. Furthermore, Z'gambo (2015) found that the proportion of construction workers reporting to use of PPE increased with work experience. These findings imply that the longer the employees are at work, the more they protect themselves from respiratory conditions due to the application of their work experience. Contrarily, Monney et al. (2014) showed no statistically significant association between work experience and the use of personal protective equipment. Correspondingly, Rupani (2023) observed that employees with 7 to 8 years of experience did not have appropriate PPE.

Worksite risk perception has influenced quarry and allied workers' respiratory protection. This current study's findings correlate with the protection motivation theory, which states that risk perception and use of personal protective equipment increase when workers have a reason for concern. In most instances, employees are cognisant of protecting themselves from respiratory conditions due to having suffered from some respiratory illness. ILO (2013) states that workers who had experienced an accident or incident in the past felt less safe and were more aware of the risks than those who had not experienced an accident or incident; hence, they are more prone to protect themselves. When workers are made aware of the hazards in their workplace, they are more inclined to use PPE to protect themselves from exposure to the hazards. Conversely, if workers are provided with PPE but are not told why or how to use PPE, likely, such PPE will not be utilised. Kumar et al. (2016) point out the importance of workers having knowledge of the hazards and risks posed by their work and how they can protect themselves from hazards. Lombardi et al. (2009) found that workers understand the risks involved in the job when they are told at the beginning that PPE is required and trained on PPE use.

5.2 Knowledge, Attitudes, and Practices of Quarry and Allied Workers on Occupational Respiratory Protection

This present study assessed the knowledge, attitudes, and practices (KAP) of quarry and allied workers on occupational respiratory protection from three Namibian regions, namely Erongo, Ozotjondjupa, and Kunene regions. Most participants in this study are men. Thus, the quarry and construction environment are dominated by men as the work requires masculine norms. Furthermore, Zin and Ismail (2015) and Ngosa and Naidoo (2016) found that the mining and construction industry is male-dominated, thus limiting women's willingness to join. The quarry and allied workers in Erongo, Ozotjondjupa, and Kunene regions are youthful (i.e., 35 years and below). These findings concur with Wanjiku et al. (2015) of the Mutonga quarry community in Kenya.

In the present study, most quarry and allied workers had inadequate knowledge of respiratory protection. The low educational attainment of most respondents can explain the inadequate level of knowledge among quarry and allied workers. Thus, most respondents might face difficulties in comprehending respiratory safety educational information. In line with the current study findings, Mrema et al. (2015) found that most participants did not know about respirable dust concentration levels, as many were unsure or did not know how to protect themselves fully. Correspondingly, Jiang and Luo (2021) found no discernible correlation between exposure and understanding of the risks and hazards associated with respirable dust.

The findings indicate that some workers were unaware of the potential risks and hazards associated with breathing in dust. Therefore, they did not know how to protect themselves from respirable dust. Similarly, Reiprich et al. (2016) asserted that if workers are not aware of the harmful effects of dust, they are unlikely to take precautions and are less inclined to protect themselves. The lack of knowledge could be attributed to the employer's failure to provide adequate information about allowable dust exposure limits and the available methods to protect employees from dust exposure. Opposing the current study findings is Aloh (2014), who found that Nigerian construction workers were aware of the respiratory risks associated with their working environment. Similarly, Ahadzi (2021) reported that gold miners acknowledge the main respiratory protection remedies following dust exposure in Ghana. Elsewhere, Geng and Saleh (2015) in China acknowledge that the mine workers knew how to protect themselves from respiratory conditions aligned with dust exposure.

With adequate knowledge of respiratory protection, quarry and allied workers can easily protect themselves from respiratory infections and conditions.

The study revealed that more than half of the Namibian quarry and allied workers had negative attitudes towards respiratory protection. The current study findings corroborate those of Aziz and Osman (2019), who discovered that Malaysian quarry workers had negative attitudes toward respiratory protection. The negativity resulted from the workers' perception that respiratory protection equipment, such as respirators, posed some challenges and brought discomfort to them; hence, they did not use it (Lancet, 2019). Similarly, in Turkey, Gürcanl, Baradan, and Uzun (2015) found that quarry miners had negative attitudes regarding occupational safety issues as they did not wear respiratory protective equipment, thus putting themselves in danger. The commonness of negative attitudes has put quarry and allied workers at risk of developing respiratory conditions. However, contrary to the current study's findings, Zin and Ismail (2015) noted positive attitudes among Kenyan construction workers who put on respiratory protection equipment and adhere to the respiratory protection program provisions. Subsequently, employees with positive attitudes can be relied on (Singh & Gupta, 2016). Thus, positive attitudes among employees are linked to a higher likelihood of exercising caution, including wearing respiratory protection equipment.

The inadequate knowledge level of respiratory protection and the negative attitudes badly influenced quarry and allied workers' practices. This study demonstrated a substantial negative correlation between quarry and allied workers' knowledge and practices (r = -0.934) on respiratory protection. These findings imply that the lack of knowledge demonstrated by quarry and allied workers resulted in bad practices. Aligned with these findings is a study by Zhou (2018) in China that revealed that a lack of knowledge of respiratory protection propagated risky practices among mine workers. Bad practices entail quarry and allied workers not protecting themselves from respiratory infections and workplace conditions. This finding implies that for miners to incorporate the risks and hazards of respirable dust exposure into good behaviour and practices, mining site management needs to impart to employees with respiratory protection knowledge and enhance awareness. Diverging from the current study findings of Sufiyan and Ogunleye (2013), who found out that knowledgeable mine workers resorted to health-protective practice measures that witnessed them wearing respirators even when it was not necessary. Additionally, Tobin et al. (2016) in Nigeria and Sufiyan and Ogunleye (2013) in Southwest Nigeria both report a positive and significant relationship between the knowledge levels of building construction workers and their use of safety practices. The rational model assumes that good or adequate knowledge among quarry and allied workers leads to positive or good respiratory protection behavioural practices, whereby employees adhere to respiratory protection guidelines.

This study established a moderately negative association between attitudes and practices (r=-0.762). Premised on the findings, the negative attitudes portrayed resulted in bad practices among Namibian quarry and allied workers. Contradicting the current study outcome is an observational study by Sifanu et al. (2023), which showed work practices and compliance with safety standards being moderated by attitudes aligned to the risks and dangers of respirable dust exposure. Sifanu et al. (2023) showed a positive association between practices and attitudes, as positive attitudes promoted good work behavioural practices, which reduced worker exposure to respirable dust. Subsequently, Beth (2018) found no significant relationships between workplace working behavioural practices and compliance attitudes toward employee respiratory protection.

The current study established a significant positive correlation between knowledge and attitudes (r=0.816). These findings infer that knowledge significantly affects employee attitudes, as supported by Keil, Richardson, Westreich, and Steenland (2018), who mention that knowledge is crucial in fostering attitudes. Inadequate knowledge among quarry and allied workers negatively affected their attitudes towards respiratory protection. Negative attitudes increase workers' exposure to respirable dust due to inadequate knowledge of associated respiratory risks and hazards. Thus, there was a lack of knowledge of Namibian quarry and allied workers not wearing masks or respirators and implementing engineering and administrative respiratory control measures. Conversely to the current study findings, Reiprich et al. (2016) indicate that positively moderated knowledge informs attitudes to lessen the impacts of respirable dust. This suggests that workers' knowledge impacts their attitudes towards exposure to respirable dust. Elsewhere, Beth (2018) found that educating employees on occupational dust exposure helps stimulate positive attitudes, which is key to preventing respiratory diseases among workers. However, diverging from the current study findings is Kumar et al. (2014), who showed no direct significant relationship between knowledge of the risks and dangers of respirable dust, as well as the attitudes of workers toward respirable dust and exposure to respirable dust.

The current study found that individual factors in marital status, age, and educational level influenced the Namibian quarry and allied workers' level of knowledge on respiratory protection. Aligned to the current study findings are Aziz and Osman (2019), who found that almost similar proportions were registered by respondents who had attained secondary education, whereby 21(51.2%) were knowledgeable on respiratory protection mainly through using appropriate PPE at work while 20 (48.8%) respondents who had primary education where not knowledgeable. However, these results differ from the findings from a study carried out among construction workers in Nigeria by Isara et al. (2016), which found that education was associated with respiratory protection knowledge, where the proportion of workers using PPE was higher among workers with primary and secondary education compared to workers with no education. These findings underscore the importance of educational level on an employee’s ability to attain knowledge.

The influence of marital status on employee knowledge was also highlighted by Guerin and Toland (2020), who revealed that Indian single construction workers were more knowledgeable about occupational respiratory protection than married workers. However, contrary to this, Arrandale et al. (2017), among Italian miners in Wittenon, found that single workers were more susceptible to respiratory conditions than married workers, as they lacked respiratory knowledge compared to married miners. Additionally, Dhatrak and Nandi (2019) discovered that married individuals had good knowledge and were noted to have a positive impact on attitude toward safe working, which involved wearing masks and respirators. The most likely explanation is that marriage entails more significant and outstanding obligations, which may make stable employment more valuable and important.

Similar to the current study's findings, the National Institute for Occupational Safety and Health (2019) found that training programmes influence employees' knowledge of respiratory protection. According to NIOSH (2019), training programmes strengthen employee skills and enhance knowledge and attitude. Kumar, Gupta, Agarwal, and Singh (2016) discovered that trained workers who were trained in specific tasks and respiratory protection were primarily responsible for their occupational well-being. Contrarily, premised on this study's findings, most Namibian quarry and allied workers are not trained in respiratory protection; hence, they are susceptible to respiratory conditions.

The present study found that the worksite and the level of education influenced Namibian quarry and allied workers' attitudes towards respiratory protection. The study did not find an association between working experience and workers' attitudes, which is similar to a binary analysis (Long, Sun, & Neitzel, 2015), which revealed no correlation between workers’ attitudes towards coal dust exposure and work experience. Therefore, the attitudes were similar among respondents with different lengths of work. However, a study by Zin & Ismail (2015) on construction workers aged 30 years and above portrayed positive attitudes toward safety protection, which was significantly associated with having good knowledge. This entails that older workers are the most compliant with safety protocols and have the lowest risk of being involved in safety malpractices, as suggested by Nguyen et al. (2021), who discovered that older workers have higher job satisfaction and a better view of safety.

The current study rules out marital status as a factor influencing employee attitudes. These findings contradict Isara et al. (2016) in the Edo State of Nigeria, who found a substantial relationship between employee attitudes and respiratory protection among married and single construction workers. This implies that married employees have more positive attitudes towards respiratory protection than single employees. Harm-Ring-Dal (2009) submit that single employees in their work environment have negative attitudes toward respiratory protection. Literature pronounces the effect of marital status on employee attitudes towards respiratory protection.

In this study, employee respiratory protection practices were significantly predicted by the level of education, working experience, and training status. This study's findings corroborate those of Mital and Ghahramani (2011), who studied the occupational respiratory profiles of Kenyan artisanal miners and found that novice workers had more risky practices in their work than seasoned employees. Similarly, Isara et al. (2016 in Nigeria, Edo State, established a significant relationship between the years of experience and safety practices (PPE) among building construction workers. Aligned to this study's findings are Donald and Young (2012), who studied the effect of personal variables on respiratory protection among British workers and found that inexperienced staff had more unsafe practices than their experienced counterparts. This finding supports the idea that the more workers stay on the job, the more they engage in safe practices using PPE, such as respirators and masks. Keil, Richardson, Westreich, and Steenland (2018) concluded that most employees' respiratory conditions occur due to novice workers.

This study did not find an effect of marital status on employee respiratory protection practices. In line with the study findings is Sifanu et al. (2023), who found no substantial difference in the usage of protective practices by married and single employees regarding their occupational hazards. This implies that, irrespective of being married by the employee, this status does not interfere with employee practices. Contrary to the current study findings, Vojakavic and Gordon (2010) reported that single employees took more precautionary practices than their married counterparts. However, Bråtveit et al. (2014) disagreed with single employees taking more precautionary measures than married workers.

5.3 Particle Filtration Efficiency of the Masks/Filters Used at Quarry Mining Sites

This study assessed the PFE of different N95 masks used in the respiratory protection of Namibian quarry workers in the three main mining regions, namely Erongo, Otjozondjupa, and Kunene. This experimental study was conducted under laboratory conditions. The results of the study indicated that the N95 masks meet the regulatory standard for filters of at least 95% of PM10, PM2.5, and other small particles up to 0.3 microns. Thus, quarry workers must understand which mask will protect them against exposure. Compared to the amount of dust that was carried through the masks, the minimal amount collected by the filters was insignificant. The net dust levels indicate that the masks did not contain much dust. The results revealed that masks were relatively dust-free when exposed to varying dust levels for a brief period. For instance, in Site G, the exposure to dust was at 0.015mg, which exceeded the technique's standard uncertainty of 0.010mg. The study showed that N95 masks bear the highest or most favourable filtration efficiency during the initial usage phases. However, with prolonged usage, the filtration efficiency recedes proportionately to increasing dust particle admittance through the filtration membrane (Mrema et al., 2015).

The use of N95 by quarry workers is only hampered by relevant issues such as the difficulty in forming and maintaining an airtight seal that diminishes fit against the face (Jiang & Luo, 2021). Additionally, factors associated with the perception of discomfort while worn, such as heat caused by exhaled breath, tightness against the face, and the additional effort required to breathe through the filter media layers of an N95, were also raised (Zhang et al., 2016). The failure to use PPE/C by most quarry workers is associated with multiple reasons, which include uncomfortable PPE, inconvenience, interference with work, and hot weather conditions (Arstad & Aven, 2017). Quarry workers were more likely to wear respirators than construction workers 39.1% and 32.5%, respectively), and charcoal workers were 3.5 times less likely to wear respiratory protection than any other category (Mrema et al., 2015). Therefore, the continued dust exposure by the quarry and allied workers emphasises the importance of filtering facepiece respirators (FFRs) in dusty environments

The dust particle analysis found that small particles less than 10 microns in size could filter through the masks. In all the samples, except for Site D, the smallest particles had a PM10 value of 100%. The results of the study revealed that the masks functioned well at first until they were subjected to prolonged use. Contradictory trends were noted in the previous study, where the dust penetrating particle size was measured around 40 nm in a laboratory experiment that used polydisperse aerosol. The average of the dust particles that penetrated the N95 masks of 40 nm size was found to surpass 5% for the two N95 masks that were being compared (Jiang & Luo, 2021). Also contrasting to the current findings are dust particles of 36.5 nm in size in blasting and concrete grinding sites (Jacobsen et al., 2021). The difference in N95 masks and dust properties triggers changes in the electrostatic charges of dust particles trapped on the filtration membrane of the masks (Zhang et al., 2016).

5.4 Review the Namibian Legal Provisions Protecting Quarry and Allied Workers from Respiratory Infections

The legislative review shows apparent gaps in the legislation or a lack of specific regulations for preventing dust-related diseases. The legislation places the responsibility for maintaining the health and welfare of mineworkers on the mine owner. The legal provisions for occupational safety and health in the mining sector, particularly regulations concerning dust control in the work environment, are vague. The legislation refers to the importance of dust control. It provides regulations for certain aspects of dust control, such as ventilation or wetting of surfaces and personal protective equipment

(PPE), but does not prescribe a holistic approach. The legislation remains silent on how the regulations will be implemented and controlled.

Namibia has not yet promulgated a primary stand-alone OSH statute that can strengthen OSH enforcement in the country. The current OSH legislation is a chapter in the Labour Act of 2007 (Act No. 11 of 2007). The scope of specific OSH regulations regulating high-risk classified sectors, services, and dangerous machines (pressure vessels, lifting equipment, motorised equipment, earthmoving equipment, etc.) is very limited, which makes it difficult for authorities to regulate and enforce them. The current OSH legislation provides penalties for continuous violations; however, the punitive measures are too lenient to serve as a deterrent. These measures do not correlate with the value of the safety and health of workers.

Only South Africa provides the mining industry with clear regulations and guidelines on how occupational hygiene systems must be designed and controlled. It is the only country with a documented process for achieving ‘zero harm’ in the mining industry. It has developed and implemented a ‘National Programme for Eliminating Silicosis’. Within this context and regarding the MHS Act, mining houses must establish and implement a Mandatory code of practice (CoP) for an occupational health programme on personal exposure to airborne pollutants. The South African CoP could serve as a model for the wider region, as it does not necessitate changes or amendments to enacted legislation but could be introduced by the competent regulator.

The Chief Medical Officer in Occupational Health and Safety does not report respiratory conditions and works alone. The paper-based reports on injuries and diseases are not systematically analysed, and statistical information on the burden of respiratory infections and conditions in the mining sector is inaccessible. Occupational health and safety systems must produce complete and valid data to analyse the national workforce´s health. Well-functioning occupational disease surveillance and notification systems provide the relevant authorities with incidence and prevalence data, which allow for the development of policies and strategies to improve workers’ health.

ILO’s List of Occupational Diseases Recommendation, 2002 (No. 194) calls for a national list of occupational diseases for prevention, recording, notification, and, if applicable, compensation to be established by the competent authority in consultation with the most representative organisations of employers and workers. The national list should indicate the specific illnesses to be recognised as occupational diseases. This national list should be regularly reviewed and updated to consider the up-to-date list of occupational diseases annexed to the ILO List of Occupational Diseases Recommendation, 2002 (No 194). This policy seeks to harmonise the national compensation and legal frameworks with the relevant international instruments.

Assessments show that the inspectorates of labour, mining, and health are not sufficiently capacitated to enforce the Labour Act. The labour, health, and mining inspectorates are understaffed, under-resourced, and do not have the necessary skills or systems to enforce the existing legislation. At the same time, extension and privatisation of the mining sectors, the control and enforcement systems have not been adapted to the new mine owners. Most inspectorates operate without any inspection fees within their departmental budgets, which limits institutional development and coverage.

The artisanal mining segment is not covered by inspections at all. This is related to human resources and budgetary constraints. The quality of dust control and occupational hygiene in medium-sized mines and quarries varies from compliance with international standards to inadequate, depending on the ownership. The weak inspection and enforcement systems largely contribute to mine owners' non-compliance. Small-scale and artisanal mines have limited dust control systems and are rarely inspected. The most problematic areas are small-scale and artisanal mines. Although the owners of these enterprises hold a valid mining license, they tend not to apply the existing mine health and safety regulations and standards issued by mining, health, or labour authorities.

There are deficiencies in risk assessments, limited access to technical expertise and equipment used to conduct hazard monitoring, and deficient management systems, leading to the inability to comply with current health and safety standards.

C081 - Labour Inspection Convention, 1947 (No. 81), requires countries to have in place labour inspection systems to secure the enforcement of the legal provisions relating to conditions of work, effective cooperation between the inspection services and other government services, and public or private institutions engaged in similar activities; collaboration between officials of the labour inspectorate and employers and workers or their organisations; and ensuring the availability of duly qualified technical experts and specialists in the inspection and workplace effective' investigation systems.

The large mining houses have set up elaborate occupational health and safety systems paired with first aid and primary healthcare, and apply the provisions made in the legislation and occupational health policy. Medium-sized and small-scale mines provide occupational health services in collaboration with registered occupational practitioners. Pre-employment and exit medical examinations usually occur in this mining segment, with periodic examinations carried out randomly. The mostly self-employed artisanal mineworkers do not undergo occupational health screenings. Where mines do not provide primary healthcare services to mineworkers (medium and small-scale mines), the public healthcare system can be accessed for a low fee.

Zambia differs from Namibia as the mandate for carrying out occupational health screening in the mining sector lies with the ‘Occupational Health and Safety Institute (OHSI)’ in Kitwe/ Copperbelt. The Institute is a regulatory body conducting medical surveillance examinations for all industries, including occupational disease diagnostics and developing occupational health promotion and prevention programs. Tanzania´s Occupational Health and Safety Authority (OSHA) is mandated to undertake occupational health surveillance for the country´s entire workforce. Surveillance activities include pre-employment and periodic “fitness to work” examinations. Surveillance services are rendered at OSHA´s premises in Dar es Salaam and through mobile teams visiting the workplaces. OSHA also outsources fitness-to-work examinations to private medical practitioners and health services (including mine, on-site services). OSHA has issued a particular guideline, the Fitness-to-Work Medical Examination Guideline, which provides an orientation to contracted medical doctors and ensures the consistency of examinations. Thus, Zambia and Tanzania are countries where occupational health screening is performed by the public sector.

In Zimbabwe, the National Social Security Authority (NSSA) has an established Medical Bureau that issues certificates of fitness (pre-employment) and validates periodic examination results submitted by any Medical Doctor in the country. Occupational health surveillance in terms of fitness-to-work examinations is mandatory in all workplaces in the country. The respective examinations are carried out by health facilities (e.g., District Hospitals), private practitioners, or mine health facilities (in the mining sector). No qualification is required, but NSSA offers a 5-day OHS training course for physicians conducting the examinations. The results of periodic examinations are forwarded to the NSSA Medical Bureau, which issues and validates certificates of fitness for periodic examinations. The Medical Bureau has recently acquired a mobile unit to target hard-to-reach mining populations with periodic occupational examinations. The mobile unit has diagnostics such as spirometry, x-rays, and vision tests.

Many smaller, medium-sized mines do not comply with OSHA criteria for compliance with regulations. Their mineworkers generally do not undergo regular “fitness to work” examinations. Health care in terms of primary care and/or the treatment of injuries and diseases takes place at public health facilities. The mine owners directly cover the costs, or the company would pay into the National Health Insurance Fund (NHIF) and expect the fund to cover the personnel's health care.

Under the Employee Compensation Act of 1941, every employer who employs one or more employees must complete a registration form and pay annual assessments to the Accident Fund established in section 64 of the Act. This implies that in the event of occupational injury or the development of any occupational condition, such as respiratory conditions, the employee is compensated. Occupational lung diseases, particularly the various forms of pneumoconiosis, are compensable in most countries. Tuberculosis is compensable in South Africa and Zambia. In other countries, it is compensable with a diagnosed pneumoconiosis or, more specifically, silicosis. However, research strongly suggests that exposure to significant levels of silica dust in high HIV prevalence settings substantially increases the risk of developing active pulmonary tuberculosis. Mineworkers in small-scale or artisanal mining are not registered, do not contribute to compensation funds, and are thus not eligible for compensation for work-related injuries or diseases. Particularly in countries like Tanzania, Mozambique, and Zimbabwe, with huge artisanal mineworker populations, this will burden the public health and social security systems when mineworkers fall sick and are left without social protection of any kind.

Compensation systems face specific constraints when implementing a proper compensation process. While the compensation of claims from work-related injuries is a relatively straightforward process, the compensation of occupational diseases evolving over time and mostly long after formal employment poses a great challenge. Apart from Zambia and South Africa, there are no systems to conduct regular medical benefit examinations for ex-mineworkers. However, even in the two countries, many mineworkers have returned to their rural homes and are lost to follow-up. There are no systems to systematically track and trace ex-mineworkers and encourage their participation in medical screening. South Africa (even though the country has the most fragmented worker compensation system, where a separate Act (ODMWA) regulates the compensation of occupational lung diseases in mineworkers) is currently developing an integrated database containing current and ex-mineworker information. This database is expected to allow for the physical tracing of mineworkers and the upload of medical information obtained during mine work, which will facilitate compensation.

The SADC "Protocol on Mining" strives to harmonise policies and procedures for mineral extraction in the mining sectors of member states and for increased regional cooperation to improve technical capacity and knowledge sharing. ILO Conventions C155, C159, C161, R`71, C176, C187, C17, and C18 highlighted in Article 12 of the Charter of Fundamental Rights in SADC have only been ratified by South Africa, Zambia, and Lesotho so far. There is no evidence that SADC or the member states, including Namibia, have tried to implement the harmonisation plan.

5.5 Chapter Summary

This chapter discusses the study findings. The findings showed inadequate respiratory protection practices among quarry and allied workers to safeguard them from respiratory infections. Quarry and allied workers displayed low knowledge levels, positive attitudes, and poor practices toward occupational respiratory protection. The particle filtration efficiency experiment dust masks at Quarry Mining Sites showed diminishing respiratory protection by masks due to prolonged usage. The review of Namibian legal provisions protecting quarry and allied workers from respiratory infections showed fragmentation, thereby ineffectively protecting the implicated employees.

Stemming from the study findings and discussions, the next chapter yields the respiratory protection framework for quarry and allied workers in Namibia.

CHAPTER 6: A FRAMEWORK FOR THE IMPLEMENTATION OF QUARRY AND ALLIED WORKERS' WORKPLACE PROGRAMMES

6.0 Introduction

This chapter outlines the developed framework for implementing the quarry and allied workers' workplace programme derived from the study findings.

<table>
<tr><td colspan="2">A FRAMEWORK FOR THE IMPLEMENTATION OF RESPIRATORY PROTECTION PROGRAMME OF QUARRY AND ALLIED WORKERS</td></tr>
<tr><td>Evaluated by:</td><td></td></tr>
<tr><td>Affiliation</td><td></td></tr>
<tr><td>Contact Person</td><td>Ms. Saima Shihepo
+264813225437</td></tr>
<tr><td colspan="2">Related legislation, policies, and regulations</td></tr>
<tr><td colspan="2">• The Constitution of the Republic of Namibia.
• National Occupational Safety and Health Policy
• Labour Act No.11 of 2007
• Government Notice No. 156 of 1997, Regulations relating to the health and safety of employees at work.
• Hazardous Substances Ordinance, No.14 of 1974.
• Employment Compensation Act. Act No. 30 of 1941
• Environmental Management Act. Act No.7 of 2007.
• Public and Environmental Health Act No. 1 of 2015
• General Health Regulations No. 121 of 1969</td></tr>
</table>

6.1 Acronyms and Abbreviations

Acronym/ Abbreviation	Explanation
HBM	Health Belief Model
PPE/C	Personal Protective Equipment and Control
ILO	International Labour Organisation
NIOSH	National Institute for Occupational Safety and Health
PEL	Permissible Exposure Limit
PFE	Particle Filtration Efficiency
HPCN	Health Professional Council of Namibia
OHS	Occupational Health and Safety

6.2 Definitions

Term	Definition
Administration control	Controls related to the safety of workers/labourers to avoid placement that is not in accordance with statutory regulations.
Allied workers	People engaged in creosoting or chemically treating lumber, operating, assembling or processing wood, metal, plastic or composition material for musical instruments, novelties, matches, tools, toys, or parts of tools, or any article that is composed of wood, metal, plastic, or composition material in whole, or part.
Construction worker	An individual employed in the physical construction of the built environment and its infrastructure.
Employer	A person or organisation that employs people.
Engineering protection	Protect workers by removing hazardous conditions or by placing a barrier between the worker and the hazard
Exit medical examination	Means a medical examination conducted on an employee upon leaving his or her employment.
Framework	A structure for the development and subsequent assessment of best practice in the management of the workplace.
Hazards	Any object, material, situation, or activity in an occupational setting that has the potential to cause harm to people or the environment.
Particulate Filter	Respirators are designed to reduce the wearer's respiratory exposure to airborne contaminants such as particles, gases, or vapours.
Periodic Medical Examination	An evaluation of your overall health status, during which your doctor will evaluate your body, organs, and their functioning.
Protective clothing and equipment	Helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.
Quarry workers	Individuals who excavate and process rock, slate, gravel, and sand from quarries and opencast mines.
Respiratory Protection	Safeguarding of workers against insufficient oxygen environments, harmful dust, fogs, smoke, mist, gases, vapours, and sprays.
Respirator Use	A device to protect you from inhaling dangerous substances, such as chemicals and infectious particles.
Risks	The likelihood that a person may be harmed or suffer adverse health effects if exposed to a hazard.
Sanitary and hygiene facilities	Toilets, showers, and washbasins are everyday features which are of great importance, especially in situations where people are deprived of their liberty, when detainees find themselves in a situation of total dependence on the authorities.
Training Programs	A structured and organized set of activities designed to develop or enhance the knowledge, skills, and competencies of individuals or groups in a specific area or subject.
Workplace	The setting where people work, such as an office or factory.

6.3 Framework Introduction

The developed framework focuses primarily on ensuring access to respiratory protection in quarry and related occupational settings characterized by well-defined hazards and employer-employee relationships. Understanding hazard details establishes appropriate respiratory protection, which reduces risk to an acceptable level based on a structured risk assessment. Quarry and allied workers constitute valuable human capital who engage in various activities that contribute to achieving the objectives of different quarry mines. The framework is created with consideration for the hazards and risks within the work environment and is developed in compliance with the provisions of the National Occupational Safety and Health Policy and the Labour Act, Act No. 11 of 2007, as amended.

6.4 Purpose/aim of the Framework

This developed framework intends to enhance the respiratory protection of quarry and allied workers, promote the implementation of engineering and administrative control, and effectively use PPE/C. This framework also provides greater compliance flexibility and clarity of procedures; employers must follow when implementing a respiratory protection program.

6.5 Objectives of the framework

- To provide a framework within which the safety, health, and environmental management of quarry and allied workers shall be governed.
- To promote, achieve, and maintain a healthy, hygienic, and safe working environment for the quarry and allied workers.
- To provide guidelines for the implementation of the framework, safe and health information, instructions, and training to enable the quarry and allied workers to work in a safe and healthy environment.

6.6 Scope of the Framework

This framework applies to the following:

- All employees (whether temporary or permanent, part-time or full-time, or on contract) work at quarry mines, construction sites, and charcoal production sites.
- All persons or contractors, suppliers, and vendors who provide services to quarry mines, construction, and charcoal production.
- All visitors to all quarry mines, construction sites, and charcoal production sites.

6.7 Framework Development Method

The development of the framework is guided by study findings obtained through questionnaires from workers, interviews from management, Particle Filtration Efficiency (PFE) experiment results, and the review of Namibian legal provisions, as shown in 6.1. Using an iterative process informed by multiple sources of data, necessary information was identified from the study outcomes to provide renewed guidance for developing the respiratory protection framework. Utilising findings elicited from questionnaires, key quantitative information was gathered from workers regarding the current protection of quarry and allied workers from respiratory infections. Qualitative information yielded from managerial staff interviews aligned with quarry and allied workers' knowledge, attitudes, and practices on occupational respiratory protection, highlighting several items that contributed to the development of the respiratory protection framework. A laboratory experiment measuring the particle filtration efficiency of the masks/filters used at quarry mining sites provided vital information that guided the conception of the respiratory protection framework. At this point, a scoping review of the Namibian legal provisions protecting quarry and allied workers from respiratory infections was integrated into the respiratory protection framework. The use of literature, theoretical, and conceptual framework models immensely contributed to the existing guidance of the respiratory protection framework.

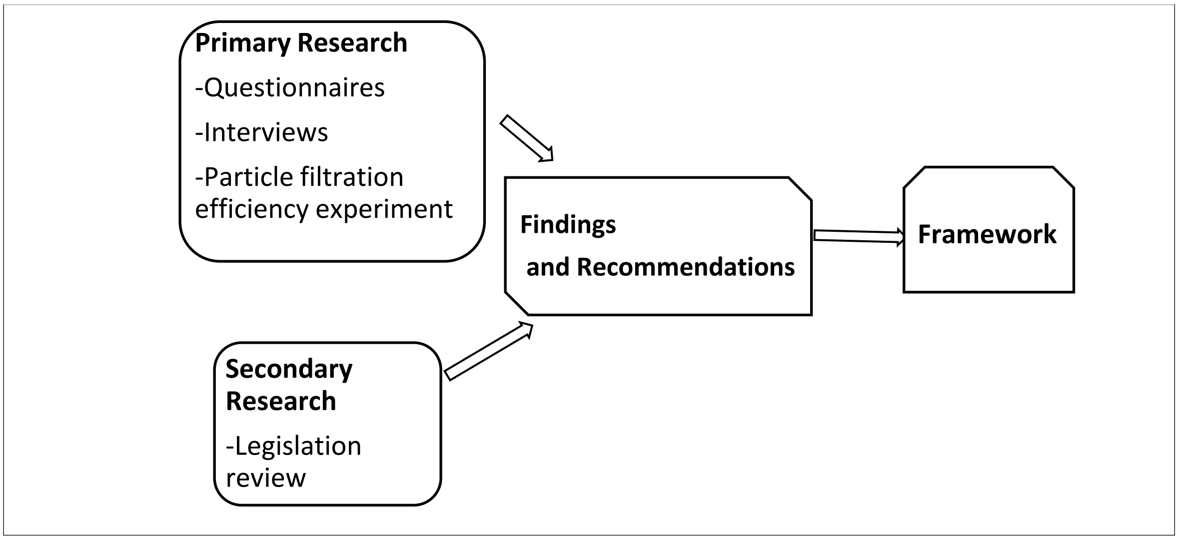

Figure 1: Methodology in framework development (Shihepo, 2024)

6.8 Benefits of the Framework

This framework necessitates the establishment and implementation of a workplace respiratory protection program (RPP) where quarry and allied workers are protected from known inhalation hazards. To quarry mines and allied industries, this respiratory protection framework helps aids in enhanced respiratory occupational organisation by providing a reference knowledge point. Antao and Pinheiro (2020) add that, based on a framework, companies are assured of a proper, consistent, and easier mode of implementation of respiratory protection measures, which aids in compliance. The current framework proffers guiding principles that are key to developing functional components of a future respiratory protection system. Burton (2020) submits that a framework is a collaborative endeavour combining innovative strategic recommendations and pathways that act as a precursor to intuitive models of employee protection and care. The respiratory protection framework model offers a valuable benchmark for considering the hazards faced by the quarry and allied workers who are marginalised by virtue of their size and general neglect from protection legislation. The respiratory improvement framework priorities stem from the affected groups hence, it is tailored to address real and relevant respiratory issues of the affected groups (quarry and allied workers) (Lancet, 2020). Accordingly, this Framework fills in respiratory protection gaps, undertaking necessary courses of corrections, enhancing employee respiratory health. In so doing, the framework will focus on the interventions that have the most value. The Framework is closely linked with national and international standard operations, as a result, the framework is at the forefront in the key spreading of harmonised practices in respiratory protection. The framework supports and analyses respiratory protection from a global perspective, hence becomes cross-cutting (Mantovani & Bocos, Are mHealth apps safe? The intended purpose rule, its shortcomings and the regulatory options under the EU medical device framework, 2021)

6.9 Structure of the Framework

The goal of the respiratory protection framework is to enable the reduction of risks associated with inhaling respirable dust. The severity of the potential adverse outcomes within the respiratory system necessitates respiratory protection.

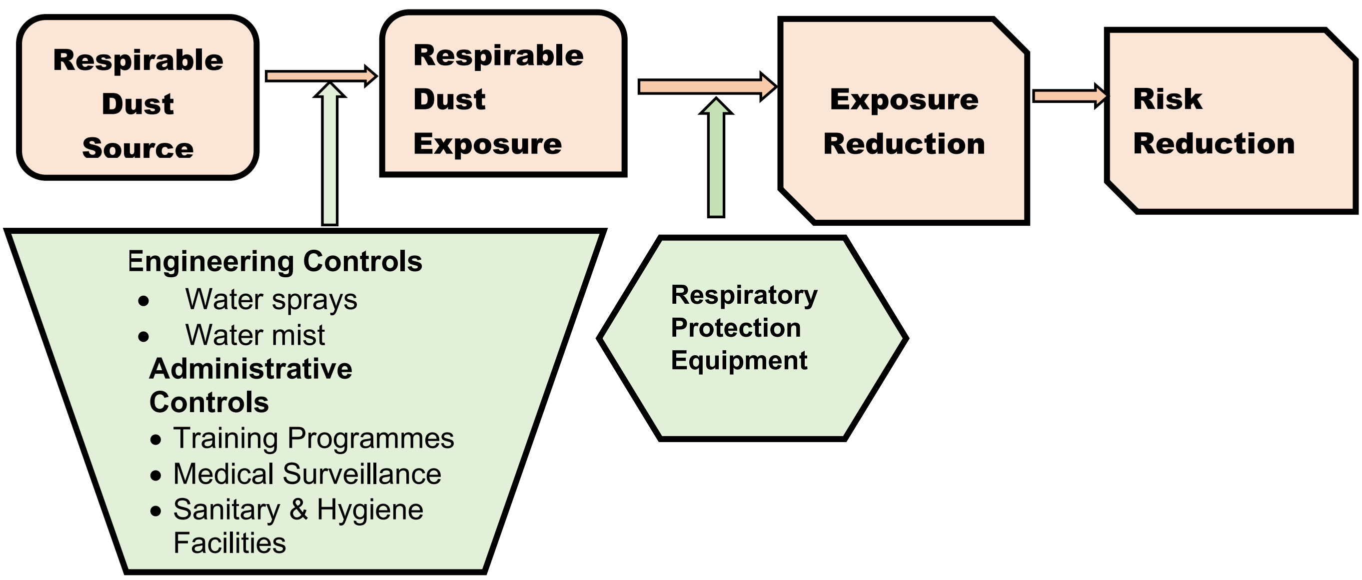

Figure 2: *Framework structure (Shihepo, 2024)*

Figure 2 delineates the risk reduction paradigm, indicating the role played by engineering and administrative controls complemented by respiratory protective equipment in reducing the risk of respirable dust exposure.

The current respiratory protection framework leverages the risk reduction paradigm, which extends from the sources of respirable dust to the consequences of exposures that increase the risk of one or more adverse health outcomes, as shown in Figure 4.2. Guerin and Sleet (2021) view risk reduction as a proactive approach in managing and minimising the potential negative consequences of uncertain events. It involves identifying potential risks, evaluating their severity and likelihood of occurrence, and implementing measures to mitigate or eliminate those risks. Aligned to the development of this respiratory protection framework, risk reduction entails adopting and implementing preventive measures and interventions to minimise the respirable dust exposure risks to quarry and allied workers. Focusing on risk reduction prevents the occurrence of respiratory conditions and infections among quarry and allied workers.

Premised on the risk reduction approach, risk identification and assessment become necessary as the study results detect the **respirable dust source** alongside its severity. Respirable dust sources entail workplace areas where dust is generated during quarry mining, charcoal production, and construction. The presence of a workplace source of respirable dust results in **respirable dust exposure,** which poses major health risks in the development of respiratory conditions and infections. Scarlet arrows depict employee risk moment from a level of high risk at the respirable dust source, decrease through controls by green arrows through exposure, until dust exposure risk is reduced by RPE as well. The study outcome showed that between the respirable dust source and period of exposure, specific preventive controls can be instituted in the operational processes to protect the workers by reducing the associated risk

Control measures (engineering and administrative) within the hierarchy of controls are directed at the connection between the source and exposure. The hierarchy of controls defines the categories of actions that can be taken to prevent workers' exposure to known inhalation hazards. The control measures initially developed for occupational settings reduce the intensity of exposure and provide the most effective protection available. In this framework, engineering controls are at the top as they are typically more effective and reach more broadly than administrative controls. Higher-level end engineering controls are designed to remove or reduce the hazard at the source, and this mainly involves the use of water sprays or wetting agents to suppress airborne contaminants. Administrative controls are designed to change how miners work, such as ensuring that miners are safely cleaning dust off their work clothes, through medical surveillance, and through respiratory protection training.

The institution of RPE is a migratory **exposure reduction** initiative that prevents the consequences of known exposures to respirable dust with identified adverse respiratory outcomes. This intervention deters the amount of hazardous agent inhaled (and, by extension, the dose received).

The risk reduction paradigm hinges on the Health Belief Model (HBM) in such a manner that individual beliefs on susceptibility, perceived benefits, and sense of self-efficacy are strongly linked to their adoption and use of preventative measures that deter respiratory health risks, such as respiratory infections and conditions. Thus, premised on the HBM, the current respiratory protection framework encourages individual (quarry allied workers) confidence to engage in beneficial respiratory protection behaviours. The HBM constructs (of perceived susceptibility, perceived barriers, perceived benefits, cues to action, and self-efficacy) greatly assess respiratory health risks and promote preventive behaviours in the respiratory framework, promoting risk reduction of respiratory infections and conditions.

6.10 Implementation process

Namibia uses an employer-based approach to occupational health and safety (which includes respiratory protection), requiring employers to ensure that their workplaces are safe and their employees are protected from hazards. This employer-based approach is outlined in the Labour Act 6 of 2007: regulations relating to the health and safety of employees at work, which mandates that employers take adequate measures to protect workers from exposure to hazards. It is the responsibility of the management of quarry, charcoal, and construction companies to designate responsibilities for enforcing the respiratory protection framework, including monitoring compliance and taking corrective actions when necessary. By doing so, quarry and related companies can appoint specific individuals or managerial staff to manage and implement the respiratory protection framework. Alternatively, the execution of the framework could be entrusted to health and safety personnel (sometimes alongside quality and environment staff) or site managers for streamlined management. The designated administrators or personnel for the respiratory protection framework should be qualified in occupational health and safety, or they should receive training to oversee the framework's implementation. However, the current framework's implementation requires the application of a systems method due to the multiple operational levels involved with various employees. This means that managerial staff or health and safety personnel must communicate the respiratory protection framework provisions to employees for execution.

6.11 Guidelines to operationalise the Framework

6.11.1 Assessment and Planning

Conduct a comprehensive risk assessment to understand the specific respiratory hazards present in the quarry environment by:

1. Identifying and documenting potential sources of respiratory infections.

2. Engaging workers in surveys and interviews to gather insights on perceived risks.

3. Developing a detailed action plan outlining objectives, timelines, and responsibilities

6.11.2 **Implementation of Control Measures**

Introduce engineering controls, administrative controls, and personal protective equipment (PPE) to minimize risks.

1. Install dust suppression systems and improve ventilation in work areas.

2. Develop work schedules to limit exposure time to hazardous conditions.

3. Provide and mandate the use of appropriate PPE, such as masks and respirators.

6.11.3 **Training & Education**

Educate workers on the importance of respiratory protection and proper PPE usage:

1. Organise regular training sessions and workshops.

2. Develop easy-to-understand educational materials and visual aids.

3. Encourage a culture of safety through regular communication and feedback.

6.11.4 **Monitoring & Evaluation**

Continuously monitor the effectiveness of implemented measures and make adjustments as needed.

1. Conduct regular health screenings and environmental monitoring.

2. Collect and analyse data on infection rates and compliance levels.

3. Review and update the framework periodically based on new findings and feedback.

6.11.5 Stakeholder Engagement

1. Collaborate with industry stakeholders, health experts, and governmental bodies to align efforts and resources by;

1. Establishing partnerships for resource sharing and joint initiatives.

2. Participating in industry forums and networks to stay informed on best practices.

3. Advocating for policy changes that support worker safety and health.

6.12 Respiratory Risks and Hazards

The quarry, construction, and allied industries are associated with negative health risks such as cardiovascular, pulmonary, neurological, renal, haematological, and musculoskeletal disorders because of excessive respirable dust inhalation. Common diseases and conditions include pneumoconiosis, fibrosis, cancer, silicosis and tuberculosis, asthma, cystic fibrosis, bronchopulmonary dysplasia, and pulmonary hypertension.

6.12 Respiratory Protection Methods for Quarry and Allied Workers

The following methods should be used to protect quarry and allied workers from the adverse health effects of exposure to respirable dust.

6.12.1 Engineering Controls

Engineering controls should be the principal method for minimising exposure to respirable dust in the workplace. Dust suppression systems using water sprays and water mist (wetting agents) are used to moisten dust ejected from mining or construction operations, thereby reducing respirable dust emissions by up to 96%. To enable the application of the wetting method, quarry, construction, and allied work sites should have a reliable supply of water (wetting agent) tailored to suppress dust emission during operations.

6.12.2 Administrative Controls

The following administrative controls are key in protecting quarry and allied workers from respiratory infections and conditions

6.12.2.1 Training Programmes

Training is key to ensure that quarry and allied workers are knowledgeable about respiratory protection to attain maximum cooperation and active participation in the respiratory protection programme. The management of quarry, construction, and allied companies should arrange respiratory training schedules that cater to all employees, for new workers from initial employment and refresher training for seasoned ones. Training should include information about measures workers can take to protect themselves from exposure to respirable dust (e.g., the use of appropriate work practices and personal protective equipment--including the emergency use of respiratory protective equipment).

6.12.2.2 Medical Surveillance Programme

Within the mining, construction, and related industries, mandatory medical examinations for each employee should be conducted. The medical examinations must be conducted covering the best practice respiratory screening, including spirometry and chest X-ray. The registered medical practitioner is responsible for ensuring a respiratory health surveillance programme is implemented for workers. This responsibility extends to workers involved in on-site operations who are not employees of the operator, e.g., contractors, labour hire workers.

Respiratory health surveillance must be undertaken at the following minimum occasions.

6.12.2.2.1 Initial Medical Examinations

Initial examinations are conducted when workers are hired for the first time and rejoin the industry, and they have not had a respiratory health surveillance medical in the previous five years. Respiratory health surveillance proffers individual worker health status baseline, assisting in the early detection of respirable dust-related illnesses and conditions that may make the miner more susceptible to the toxic effects of respirable dust. This examination ascertains whether the new employees are able or not to work under respirable dust conditions.

6.12.2.2.2 Periodically Medical Examinations

Periodic examinations are conducted annually, comparing with initial examination results to ascertain the possibility of any existing respiratory condition or disease. The maximum period between respiratory health surveillance must not be more than five years for current workers. Respiratory health surveillance is required when employees change sites, if the risks change before the date of the next respiratory health surveillance.

6.12.2.2.3 Exit Medical Examinations

A worker who is permanently stopping work in the industry should be accompanied by an exit respiratory health surveillance. The retiring worker must have worked in the industry for at least three years and not have had a respiratory health surveillance medical during the last three years.

6.12.2.2.4 Medical Examination Payment

The employer must pay for the health surveillance cost. It is key that quarry, construction, and allied industries liaise with local district hospitals for medical surveillance for convenience and affordability.

6.12.2.2.5 Documentation and Reporting

The medical records and clinical results of the respiratory health surveillance examinations should be documented, recorded safely, and a report must be produced that describes the outcome.

6.12.3 Sanitary and Hygiene Facilities

Workers should be provided with and advised to use facilities for showering and changing clothes at the end of each work shift. Employers should provide lockers or other closed areas for workers to store their home clothes separately. The sanitary and hygiene facilities should cater to separate sexes.

6.12.4 Respirator Use

The employee shall be furnished with a NIOSH-approved respirator that is applicable and or suitable for the purpose intended, and the employee shall use it following training and instructions. Multiple respirators should be available, depending on which hazardous substance the quarry and allied workers are exposed to.

6.12.4.1 Respirator Selection

The selection of respirators follows the permissible exposure limit (PEL). This means that all quarry, construction, and allied industries should invest in a workplace dust monitoring system that establishes each workplace PEL to enable the selection of the correct respirator. The following respirators are recommended for quarry and allied workers.

Particulate respirator/ filtering facepiece (NIOSH-approved) (e.g., N95, N99, P-100) with the entire facepiece composed of the filtering medium is the least form of respirator to be used. The respirator requires a tight seal between the respirator and the face and/or neck of the user to work properly, which has negative air pressure concerning the ambient air outside the respirator during inhalation. Should be disposed of and replaced with a new one each time they are removed. Medical clearance and fit testing are not required.

Half and full-face Mask Air-Purifying respirators are enhanced particulate respirators/ filtering facepieces with tight-fitting and air-purifying filtration. Test fitting and medical evaluation are required

6.12.4.2 Respiratory Fit Testing

Proper fit testing is necessary to ensure that the respirator selected is offering sufficient protection from hazardous inhalants as well as minimising discomfort. Respirator fit testing confirms the correct mask size without air leaks. A fit test is required whenever a different make or size respirator is used or when the facial characteristics of the employee change

6.12.4.3 Respiratory Medical Evaluation

A medical evaluation must be performed on every employee required to use a respirator to determine whether the employee can use a given respirator. Medically evaluating employees before respirator use assesses medical and psychological conditions; hence, the employers will avoid exposing employees to physiological stresses.

Locally available licensed healthcare professionals, both physicians and nonphysicians (accredited by the Health Profession Council of Namibia), can evaluate employees for respirator use to the extent authorised by the scope of their practice.

NB: Dust masks (non-NIOSH approved), which are loose-fitting, are not to be used by quarry workers; however, construction workers can use them. Quarry mines generate more harmful dust than construction sites

Generally, the use of respirators is commonly affected by fit factors such as facial hair. Employees wearing half-mask and full-facepiece respirators should be clean-shaven or free from excessive facial hair, including stubble and wide sideburns, as these facial characteristics interfere with a tight seal between the facepiece and the employee's face, allowing contaminated air to be inhaled.

6.12.5 Protective Clothing and Equipment

Complementing general OHS, workers should be given and wear overalls, gumboots, face shields, ear protection, or similar full-body coverings. Employers should also ensure that protective clothing is inspected and maintained to preserve its effectiveness. This entails that companies should employ health and safety personnel who undertake such duties.

6.13 Evaluation process

Respiratory protection is best realised when injury and illness prevention allows for hazard identification, development of prevention and control measures to address these hazards, and ongoing evaluation of the framework's efficacy. The term evaluation is defined by Stern as any activity that, throughout the planning and delivery of innovative programmes, enables those involved to make judgments about the starting assumptions, implementation processes, and outcomes of the innovation concerned.

The development of the respiratory protection framework of quarry and allied workers was accomplished under the guidance and supervision of the academic project supervisors and occupational hygienists within the mining and construction industries. Periodic feedback and recommendations were provided, which contributed to the finalisation of the framework.

The framework was also evaluated by experts knowledgeable in mining, construction, and charcoal production, specialising in respiratory protection. Both hard and soft copies of the framework were sent to these experts to familiarise themselves with the same. A print-screen copy of the respiratory protection data repository and the evaluation criteria were shared with six evaluators. Furthermore, the process of the framework development, the purpose, concepts, definitions, structure, and assumptions of the framework were presented virtually to the evaluators. Subsequently, the surveillance framework was evaluated using a tailor-made checklist for addressing common concerns for validation of research models, as recommended by Chinn and Kramer (2011:196 205):

Clarity of the framework

1. Do you think the framework is easy to understand?
2. Are the objectives achievable?
3. Are the objectives practical?

The framework was rated as easy to understand, with achievable objectives. It was further indicated that the framework is user-friendly and could be implemented in a practical setting of the quarry and allied industry.

The generality of the framework

4. Can this framework be applied in other situations?

The evaluation team regarded the framework as designed for Quarry and Allied workers only.

Accessibility of the framework

5. Do you think the framework is essential and significant to the Quarry and Allied workers?

The evaluation team regarded the framework as essential and significant to quarry and allied workers as it directly affects their safety, well-being, rights, and long-term livelihood.

Significance and usefulness of the framework

6. How relevant is the framework?

Lastly, the framework was considered as relevant to Quarry and Allied workers as it defines safety protocols, reduces accident rates, and ensures compliance with the local/national safety laws. The evaluation team further explained that the framework sets guidelines for responsible mining and construction practices.

Premised on the evaluation findings, the respiratory protection framework demonstrates clarity and significance in the Namibian context. The developed framework focuses primarily on ensuring access to respiratory protection in quarry and allied occupational settings characterised by well-defined hazards and employer-employee relationships. Understanding hazard details establishes appropriate respiratory protection, which reduces risk to an acceptable level based on a structured risk assessment.

6.14 Chapter Summary

The chapter outlined the developed framework for utilisation by the quarry and allied workers' workplace program derived from the study findings. The framework discusses its purpose and aims and briefly mentions its objectives, which include goals such as providing guidelines for the implementation of the framework, safe and healthy information, instructions, and training to enable quarry and allied workers to work in a safe and healthy environment.

The implementation and evaluation process indicates how the framework will be applied in the work setting. The next chapter will present the conclusions drawn from the study's findings and unique contributions to the body of knowledge. It will also address the limitations experienced during the study before examining the study recommendations.

CHAPTER 7: CONCLUSION, UNIQUE CONTRIBUTIONS TO THE BODY OF KNOWLEDGE, STUDY LIMITATIONS, AND RECOMMENDATIONS

7.0 Introduction

This chapter presents the conclusions drawn from the study's findings and unique contributions to the body of knowledge. The chapter will also touch on the study limitations that were experienced during the study before looking at the study recommendations. The objectives of the study were to:

- Assess the current practices in protecting quarry and allied workers from respiratory infections.
- Evaluate the knowledge, attitudes, and practices (KPA) of quarry and allied workers on occupational respiratory protection.
- Measure the particle filtration efficiency of the masks/filters used at quarry mining sites.
- Review the Namibian legal provisions protecting quarry and allied workers from respiratory infections.
- Develop a framework that guides the protection of quarry and allied workers from occupational respiratory infections.

7.1 Conclusions

The study conclusions were presented as per the achieved research objective.

7.1.1 The Current Practices in Protecting Quarry and Allied Workers from Respiratory Infections

The study revealed that quarry operators and construction companies could not effectively implement engineering controls to reduce workers' exposure to respirable dust using sprays and water mists. Most allied and quarry workers did not undergo the mandatory medical examination. This contradicts the claim made by NIOSH, which argued that construction and mining companies should provide new employees with such examinations. Despite being mandated by the Labour Act of Namibia to provide protective equipment, most workers were not given the necessary equipment. Without proper equipment, workers risk experiencing respiratory conditions that are detrimental to their health. The study found that the type of PPE used by workers in Namibia is biased toward protecting the general body instead of the respiratory system. Few workers use a respirator, so their protection level becomes low. This could result in adverse health effects because of exposure to dust. The study revealed that none of the employees had obtained a fit test. Allied and quarry workers in Namibia are not protected against dust and air contamination. The study showed that less than half of the employed individuals had adequate protection due to their facial hair. The study supports the protection motivation theory, which states that workers tend to use more protective equipment when concerned about their safety.

7.1.2 Quarry and Allied Workers KAPs on Occupational Respiratory Protection

The study further revealed that most quarry workers had inadequate knowledge of the need for protection against respiratory ailments. Their low educational level supported this. They were even unaware of the risks and hazards of respirable dust to their health. Most of the workers showed negative attitudes toward respiratory protection. This nonchalant attitude towards the need to protect and safeguard their health is corroborated by their level of literacy as well as the failure of the employers to provide necessary health information and education in this regard. The study revealed a significant negative correlation between workers' knowledge and practices (r=-0.934) on respiratory protection. In addition, a negative association between attitudes and practices (r=-0.762) was established in this study. Because of this, the bad practices displayed by workers toward health protection resulted from their negative attitudes. Surprisingly, however, a significant positive correlation was obtained between knowledge and attitudes (r=0.816). This means that the provision of adequate information by employers on respiratory hazards posed by dust to employees will positively influence their attitudes toward the need to protect themselves.

7.1.3 Particle Filtration Efficiency of the Masks/Filters Used at Quarry Mining Sites

This study measured the PFE of the different N95 masks used in Namibian quarry mines. Diverse materials used in manufacturing N95 masks possess different filtration efficiency capacities. Within the Namibian quarry mines, all N95 masks effectively protected quarry workers; however, extended use of masks diminished the filtration efficiency of the N95 masks.

7.1.4 Namibian Legal Provisions Protecting Quarry and Allied Workers from Respiratory Infections

The legislative review shows clear gaps in the legislation or a lack of specific regulations for preventing dust-related diseases. The legislation places the responsibility for maintaining the health and welfare of mineworkers on the mine owner. The legal provisions for occupational safety and health in the mining sector, particularly regulations concerning dust control in the work environment, are vague. The legislation refers to the importance of dust control and provides regulations for certain aspects of dust control, such as ventilation or wetting of surfaces, and personal protective equipment (PPE), but does not prescribe a holistic approach. The legislation remains silent on how the regulations will be implemented and controlled.

7.2 Novelty/Unique contributions to the body of knowledge

1. First Integrated Framework for Namibia's Quarry Sector

This is the first known framework specifically developed for the protection of quarry and allied workers in Namibia from occupational respiratory infections.

2. **Combines Engineering, Administrative, and PPE Controls**

Unlike existing systems that focus only on PPE, this framework integrates engineering controls (e.g., wet drilling, dust suppression) and administrative measures (e.g., health surveillance, training) with PPE use, reflecting a more holistic approach based on the hierarchy of controls.

3. **Behavioural Theory-Driven Design**

The framework is grounded in three behavioural models—Health Belief Model (HBM), Theory of Planned Behaviour (TPB), and Transtheoretical Model (TTM)—which are rarely applied together in OHS design. This multidimensional behavioural lens enhances its ability to promote real, lasting changes in worker and employer behaviour.

4. **Data-Driven and Locally Contextualised**

The framework was developed from empirical research involving 304 Namibian quarry workers, interviews, and legal reviews. This context-specific tailoring makes it more relevant and actionable than imported, one-size-fits-all solutions.

5. **Adaptable to Other High-Risk Industries**

While designed for the quarry sector, the framework's modular design allows adaptation for other dusty industries (e.g., construction, mining, cement production) in Namibia and similar settings.

6. **Educational Component Integration**

The inclusion of structured training modules, health promotion campaigns, and behaviour change communication is innovative in combining the technical and human dimensions of risk management

7. **Bridges Theory and Practice**

The framework not only contributes academically through theoretical synthesis but also delivers a practical, ready-to-implement tool that stakeholders can immediately use in occupational health programs.

7.3 Limitations of the study

1. **Laboratory Testing Conditions**

   A controlled lab environment may not fully reflect real-world mask use in dusty, humid, or extreme outdoor settings. Field-testing of mask efficacy was limited by resource constraints.

   Mitigation: Portable testing equipment was used to assess mask efficacy in these settings.

2. **Geographic Scope**

   Three (3) regions (Erongo, Otjozondjupa, and Kunene) were used for the study setting, which may not represent national variations in practices or exposures.

   Mitigation: Pilot studies were done in a new area before full-scale implementation.

3. **Lack of Longitudinal Data Cross**

   A cross-sectional design only captures a snapshot in time; it doesn't track changes or improvements over time.

   Mitigation: The Framework implementations will be evaluated from time to time.

   Focused on a specific target group

   Only small-scale quarry and allied workers, as they do not have policies and procedures in place.

   Mitigation: Starting with a smaller scope will allow for more controlled and precise findings before expanding.

   Focusing on a specific group can provide deeper insights into niche issues that broader studies might overlook.

7.4 Recommendations

The following recommendations are given:

7.4.1 Recommendations to Management of quarry and allied workers (Managerial and operational level)

Based on the study results, quarry workers should use masks with the greatest PFE. Adding to the frequent changing of N95 masks, the essence of correct mask fitting is underscored. It is suggested that all quarry sites implement fit testing to ensure that workers have the proper seal on their masks. The filtration efficiency method is important for those with facial hair, as air leakage can severely affect the effectiveness of a mask. In addition to regular fit testing, tight-fitting masks can also help reduce the risk of dust exposure.

7.4.2 Recommendations to the Ministry of Health and Social Services (MoHSS), Policymaking level/legislators

Within quarry mine environments, legislative provisions should enforce the utilisation of high filtration-performing filters and masks (P100 and N95) to protect quarry workers from respiratory complications effectively. Additionally, innovation in filter and mask designs should ensure user comfort, mainly by easing wearing and breathing.

7.4.3 Recommendations for **Future Research**

Future research should emphasise the total protective efficiency of the mask/filter, considering vital facets such as the extent to which the filter or mask fits an individual and the seal on the face of the user.

7.5 Chapter Summary

The Chapter discussed the study conclusions presented as per the achieved research objective, followed by the study limitations, novelty/ unique contributions to the body of knowledge, and recommendations.

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APPENDICES

APPENDIX A: CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

DEVELOPING A REGULATORY FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA

I am **Saima Shihepo,** a Doctor of Philosophy in Health Sciences at the Namibia University of Science and Technology. I wish to conduct a research project with the title as stated above. The objectives of the study are to

- Assess the current practices in protecting quarry and allied workers from respiratory infections
- Evaluate quarry and allied workers' knowledge, attitudes, and practices (KPA) on occupational respiratory protection.
- Measure the particle filtration efficiency of the masks/filters used at quarry mining sites.
- Review the Namibian legal provisions protecting quarry and allied workers from respiratory infections
- Develop a framework that guides the protection of quarry and allied workers from occupational respiratory infections. The questionnaire will take approximately 20 -30 minutes of your time.

Your participation is voluntary, and you can withdraw or refuse to participate in the study at any time without any penalties. Your identity will not be revealed during the study or during reporting the study findings. The researcher and the supervisor are the only persons accessing the data collected.

If you have any questions or concerns regarding the research, please feel free to contact Ms. Saima Shihepo at the cell phone number 0813225437 or by email at mis.shihepo@gmail.com. You may also contact my supervisor, Prof Omotayo Awofolu, at 061 207 2500.

Participants consent:

I have read the above information and agree to participate in the research study of my own will.

Participant's signature …………………………..signed at ----------------------------- Date: ----------------------

APPENDIX B: QUESTIONNAIRE

Good day

I am **Saima Shihepo,** a student from Namibia's University of Science and Technology, studying towards a Doctor of Philosophy in Health Science; I am conducting a study titled "**DEVELOPING A REGULATORY FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA**."

Your response to this research will be anonymous, and all data will be confidential. The shared information will only be reported as group data and used exclusively for academic purposes. Therefore, you are encouraged to answer the questions as honestly as possible.

Instructions for completing the questionnaire: Please indicate your responses based on your knowledge by placing an "X" or a checkmark next to the corresponding response. Kindly fill out this questionnaire, as the researcher will collect the completed questionnaires once you have finished.

Thank you for your cooperation and support.

Participants Code: ______ Site:____________ Date:__________________________

SECTION A: DEMOGRAPHIC CHARACTERISTICS

1. Age

18-24 years	25-34 years	35-44 years	45-54 years	55-65 years

2. Gender

Male	Female

3. Marital status

Single	Married

4. Level of education

None	Primary	Secondary	Tertiary

5. Employment Status

Full time	Part-time

6. Years of working experience

Less than a year	1-3 years	4-7 years	7-10 years	More than 10 years

7. Type of duty engaged (Job category)

____

SECTION B: EMPLOYEE RESPIRATORY PROTECTION

8. Engineering controls

Are the following engineering controls applied at your workplace?	Yes	No
Water Sprays (wet drilling)		
Water Mists		

9. Employee educational awareness/training

Are the following training and education initiatives implemented?	**Yes**	**No**
Are you aware of any respiratory protection, health, and safety guidelines or company policies?		
Are you trained on the importance, use, and care of PPE/C aligned with respiratory protection?		

10. Medical surveillance measures

Are the following medical surveillance measures applied at the workplace?	Yes	No
Pre-employment medical check-ups		
Periodic medical examination		

11. Hygiene enabling facilities

Are the following hygiene-enabling facilities present at your workplace?	Yes	No
Adequate handwashing facilities		
Separate sex showers are supplied with hot and cold water.		
Clean change areas with separate storage facilities for PPE/C and personal clothes.		

12. **Provision and experiences associated with PPE/C usage**

Question	Yes	No	I do not know
Are you provided with PPE/C?			
If YES, do you pay for PPE/C?			
	Always	Not at all	Sometimes
How do you often use PPE/C?			
	Yes	No	I do not know
Do you experience problems in using PPE/C?			

13. Type of PPE/C Provided

Tick the type of PPE/C provided to you

Respirators only	

Masks only	
Overalls and masks only	
Goggles only	
Overalls only	
Respirators, Masks, and Overalls	

14. Respirator Fit Testing

Is your respirator test fitted before use?

Yes	No

15. Do you bear the following?

	Yes	**No**
Excessive facial hair		
Beards		
Sideburns		

SECTION C: EMPLOYEE KNOWLEDGE, ATTITUDES AND PRACTICES ON RESPIRATORY PROTECTION

16. Employee knowledge of respiratory protection

	Yes	**Not sure**	**No**
Using a mask or respirator can prevent respirable dust inhalation.			
Before using respirators for the first time, it is necessary to be medically evaluated.			
Having facial hair (beard) or acne has a negative influence on the protective performance of the respirator.			
I can correctly don and doff the respirators (adjust respirators on the face, grab the bands in doffing)			

17. Employee attitudes on respiratory protection

	Strongly Disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
I believe employees and employers are fully responsible for the respiratory protection of employees in the workplace.					
I think workers' health check-ups should be done periodically.					
Respiratory protection is a top priority when I do my work.					

I think using PPE/C is important for respiratory protection.					
I believe occupational health and safety campaigns are effective in promoting respiratory protection.					

18. Employee practices on respiratory protection

	Always	**Sometimes**	**Never**
I wear respiratory protection while doing my work.			
I test-fit my mask or respirator to ensure it fits properly.			
I clean my respirator at the end of my shift or whenever necessary.			
I leave the contaminated area when the mask or respirator does not protect adequately.			
I tell the employer if I do not have respiratory protection.			
I take a bath daily after work.			

The end

Thank you

APPENDIX C: INTERVIEW GUIDE

Number ….

DEVELOPING A REGULATORY FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA.

Dear Respondent,

I am a student from Namibia's University of Science and Technology, studying towards a Doctor of Philosophy in health science. I am conducting a study on "developing a regulatory framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia." Information collected will be considered strictly confidential and only be used for research purposes. Please sign below if you are willing to participate.

I hereby verify that I am willing to participate in the study.

Signature.....................................

Date.........................

1. Does your work process produce any Dust?
2. What measures do you have in place to control dust generation?
3. What legal document is guiding you in protecting workers from occupational respiratory infections?
4. Do you conduct medical checkups for your workers?
5. How many times is it done?
6. What standard operating procedure guides your protection from occupational injuries?
7. Do you provide training for your workers on the use of PPE?
8. Are all your employees provided with PPE?
9. Do you sell the PPE/C to your employers?
10. What engineering control measures are in place to protect workers from Dust exposure?
11. What hygiene-enabling facilities are present at your workplace?
12. Do you take your employees for medical check-ups? How many times?
13. How is your employee's knowledge and understanding of PPE/C?
14. How is your employee's attitude towards PPE/C?

Thank you for your time

APPENDIX D: APPROVAL LETTER TO CONDUCT THE RESEARCH STUDY

REPUBLIC OF NAMIBIA

MINISTRY OF HEALTH AND SOCIAL SERVICES

OFFICE OF THE EXECUTIVE DIRECTOR

Ministerial Building
Harvey Street
Private Bag 13198, Windhoek

Tel: No: 061 -203 2507
Fax No: 061-222 558
Andreas.Shipanga@mhss.gov.na

Ref: 22/4/2/3
Enquiries: Mr. A. Shipanga

Date: 09 August 2022

Ms. Saima Shihepo
PO Box 1339
Okahandja
Namibia

Dear Ms. Shihepo

Re: Developing a regulatory framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia.

1. Reference is made to your application to conduct the above-mentioned study.
2. The proposal has been evaluated and found to have merit.
3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**
   - 3.1 The data to be collected must only be used for academic purpose;
   - 3.2 No other data should be collected other than the data stated in the proposal;
   - 3.3 Stipulated ethical considerations in the protocol related to the protection of Human Subjects should be observed and adhered to, any violation thereof will lead to termination of the study at any stage;
   - 3.4 A quarterly report to be submitted to the Ministry's Research Unit;
   - 3.5 Preliminary findings to be submitted upon completion of the study;
   - 3.6 Final report to be submitted upon completion of the study;
   - 3.7 Separate permission should be sought from the Ministry for the publication of the findings.
4. All the cost implications that will result from this study will be the responsibility of the applicant and **not** of the MoHSS.

Yours sincerely,

BEN NANGOMBE
EXECUTIVE DIRECTOR

All official correspondence must be addressed to the Executive Director.

My NAMIBIA

APPENDIX E: APPROVAL LETTER TO CONDUCT THE RESEARCH STUDY

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Health, Natural Resources and Applied Sciences

School of Health Sciences

13 Jackson Kaujeua Street
Private Bag 13388
Windhoek
NAMIBIA

T: +264 61 207 2970
F: +264 61 207 9970
E: dchs@nust.na
W: www.nust.na

DECISION/FEEDBACK ON RESEARCH PROPOSAL ETHICAL CLEARANCE

Dear Prof/Dr/Mr/Ms/Other(s): Saima Shihepo

Student No (if applicable): 200806483

Research Topic:	Developing A Framework For The Protection Of Quarry And Allied Workers From Occupational Respiratory Infections In Namibia
Supervisor (if applicable):	Prof Omotayo Awofolu
Co-supervisor(s): if applicable	Dr Roswitha Mahalie
Qualification registered for (if applicable):	PhD in Health Sciences

Re: Ethical screening application No: FHAS:19/2021

The Research Ethics Screening Committee has reviewed your application for the above-mentioned research project. Based on the recommendation of the expert reviewer, the research as set out in the application is hereby:

(Indicate with an X)

Approved: i.e. may proceed with the project	X	
Approved provisionally: i.e. may proceed but subject to compliance with recommendation(s) listed below		
Not approved: Not to proceed with the project until compliance with recommendation(s) listed below and resubmit ethics application for consideration		
IS MINISTRY OF HEALTH & SOCIAL SERVICES (MoHSS) APPROVAL REQUIRED?	YES:	NO: X

It is important to note that as a researcher, you are expected to maintain ethical integrity of your research, strictly adhere to the ethical policy of NUST, and remain within the scope of your research proposal and supporting evidence as submitted to the REC. Should any aspect of your research change from the information as presented, which could have an impact or effect on any research participants/subjects/environment, you are to report this immediately to your supervisor or REC as applicable in writing. Failure to do so may result in withdrawal of approval. Kindly consult your supervisor or HoD if you need further clarification.

We wish you success in your research endeavour and are of the belief that it will have positive impact on your career as well as the development of NUST and the society in general.

Ethical issues that require compliance/ must be addressed: None		
No.	**Ethical issues**	**Comment/recommendation**
1.		
2.		

NB: May attach additional page as required

Reviewrs name: **Dr Larai Aku-Akai** Signature: Date: **19 August 2021**

Full Name: Dr Larai Aku-Akai Signature: Date: **19 August 2021**
Chair: Ethics Screening Committee

APPENDIX E: LANGUAGE EDITING CERTIFICATE

EB
EDIBEST

LANGUAGE EDITING CERTIFICATE

THIS CERTIFIES THAT THE DOCUMENT WITH THE TITLE LISTED BELOW HAS BEEN EDITED FOR PROPER ENGLISH LANGUAGE, GRAMMAR, PUNCTUATION, SPELLING AND OVERALL STYLE. STUDENT HAD TO ADHERE TO COMMENTS. IT REMAINS THE STUDENT'S RESPONSIBILITY TO SUBMIT THE EDITED VERSION.

TITLE:

A FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA

NAME:

Salma Shihepo

DATE ISSUED:

23 JANUARY , 2025

B Kruger

Doctor of Management

Professional Editors' Guild/SAWC:9751

APPENDIX F: SIMILARITY INDEX

Saima 2nd Submission

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APPENDIX G: VERBATIM TRANSCRIPT OF INTERVIEWERS

1. Interview Guide

Number ….

DEVELOPING A REGULATORY FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA.

Dear Respondent,

I am a student from Namibia's University of Science and Technology, studying towards a Doctor of Philosophy in health science. I am conducting a study, "Developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia." The information collected will be considered strictly confidential and will only be used for research purposes. Please sign below if you are willing to participate.

I hereby verify that I am willing to participate in the study.

Signature.....................................

Date.........................

1. Does your work process produce any kind of Dust?
2. What measures do you have to control dust generation?
3. What legal document guides you about the protection of workers from occupational respiratory infections?
4. Do you conduct medical check-ups for your workers?
5. How many times is it done?
6. What standard operating procedure guides your protection from occupational injuries?
7. Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?
8. Are all your employees provided with PPE?
9. Do you sell the PPE/C to your employers?
10. What is the highest education level for your employees?
11. Do your employees have an understanding of respiratory protection?
12. How is your employee's attitude towards Personal Protective Equipment?
13. How often do your workers utilise their Protective equipment?
14. Do your workers comply with the use of Protective equipment?

Thank you for your time!!!

Manager Interview Responses (11 Sets

Manager Response #1

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 1: *Good morning, ma'am, welcome, please go ahead.*

Researcher: Researcher: Does your work process produce any kind of Dust?

Respondent 1: *Yes, the crushing and drilling processes produce a significant amount of dust.*

Researcher: What measures do you have to control dust generation?

Respondent 1: *We use water sprays and dust suppression units.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 1: *We use the Namibian Labour Act and health regulations.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 1: *Yes, especially during recruitment and annually.*

Researcher: How many times is it done?

Respondent 1: *Annually.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 1: *We follow internal SOPs for occupational safety.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 1: *Yes, new workers are trained during induction.*

Researcher: Are all your employees provided with PPE?

Respondent 1: *Yes, PPE is provided to all staff.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 1: *No, we provide them free of charge.*

Researcher: What is the highest education level for your employees?

Respondent 1: *Mostly secondary education without passing.*

Researcher: Do your employees have an understanding of respiratory protection?

Respondent 1: *No, their understanding is very limited.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 1: *Mixed—some positive, others negative.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 1: *Inconsistent, mostly during supervision.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 1: *Compliance is partial.*

<u>**Manager Response #2**</u>

Researcher: Good morning sir, I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 2: *Good morning, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 2: *Yes, dust is produced during blasting and excavation.*

Researcher: What measures do you have to control dust generation?

Respondent 2: *Periodic wetting of work areas with water trucks is done.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 2: *Our guide is the Occupational Health and Safety Act.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 2: *Yes, pre-employment and random screening are done.*

Researcher: How many times has it been done?

Respondent 2: *Every two years.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 2: *The Company's safety management manual guides us.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 2: *Yes, but refresher courses are rare.*

Researcher: Are all your employees provided with PPE?

Respondent 2: *Yes, it's standard for employment.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 2: *No, PPE is part of the employment package.*

Researcher: What is the highest education level for your employees?

Respondent 2: *Some have grade 10; a few finished grade 12.*

Researcher: Do your employees have an understanding of respiratory protection?

Respondent 2: *Partially, especially among experienced staff.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 2: *Experienced workers show a good attitude.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 2: *Varies—some wear it daily, others rarely.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 2: *Observed poor consistency.*

<u>Manager Response #3</u>

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 3: *Good morning, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 3*: Certainly, we deal with dust daily from rock-breaking activities.*

Researcher: What measures do you have to control dust generation?

Respondent 3: *We have implemented windshields and dust barriers.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 3: *We comply with MSHA recommendations.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 3: *Yes, check-ups are done every two years.*

Researcher: How many times is it done?

Respondent 3: *At recruitment and when necessary.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 3: *Our mine health and safety policy outlines procedures.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 3: *Yes, but only when the budget allows.*

Researcher: Are all your employees provided with PPE?

Respondent 3: *Yes, workers are issued PPE upon joining.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 3: *No, it's considered a legal obligation.*

Researcher: What is the highest education level for your employees?

Respondent 3: *Low education levels, mostly dropouts.*

Researcher: Do your employees understand respiratory protection?

Respondent 3: *Generally low due to poor education.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 3: S*ome view PPE as burdensome.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 3: *Only when prompted by the foreman.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 3: *Often not worn correctly.*

Manager Response #4

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 4: *Good morning, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 4: *Yes, especially during dry seasons when dust control is harder.*

Researcher: What measures do you have to control dust generation?

Respondent 4: *Using chemical dust suppressants in haul roads.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 4: *There's no detailed respiratory law, so we use general safety regulations.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 4: *Yes, but only for specific roles with dust exposure.*

Researcher: How many times is it done?

Respondent 4: *Once during hiring.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 4: *We use international ISO-aligned SOPs.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 4: *Yes, sporadic training sessions are held.*

Researcher: Are all your employees provided with PPE?

Respondent 4: *Yes, and we track replacements.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 4: *No, PPE cost is on the company.*

Researcher: What is the highest education level for your employees?

Respondent 4: *The Majority did not complete high school.*

Researcher: Do your employees understand respiratory protection?

Respondent 4: *Not well; most need constant reminders.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 4: *Many avoid using masks.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 4: *Sometimes neglected due to heat.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 4: *Some don't follow PPE rules.*

<u>Manager Response #5</u>

Researcher: Good afternoon, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 5: *Good afternoon, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 5: *Yes, during transportation and tipping of material.*

Researcher: What measures do you have to control dust generation?

Respondent 5: *Routine water spraying during drilling activities.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 5: *The company's HSE policy serves as our primary guide.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 5: *Yes, through a contracted medical service.*

Researcher: How many times is it done?

Respondent 5: *Every 18 months, ideally.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 5: *Daily toolbox talks are part of the SOP.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 5: *Yes, mostly when incidents occur.*

Researcher: Are all your employees provided with PPE?

Respondent 5: *Yes, and it's inspected periodically.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 5: *No, and disciplinary action is taken if not used.*

Researcher: What is the highest education level for your employees?

Respondent 5: *Basic literacy levels only.*

Researcher: Do your employees understand respiratory protection?

Respondent 5: *Low comprehension of proper usage.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 5: *Positive among trained staff.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 5: *Regular for high-risk tasks only.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 5 : *Compliance depends on oversight.*

<u>Manager Response #6</u>

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 6*: Good morning, ma'am, welcome, please go ahead*.

Researcher: Does your work process produce any kind of Dust?

Respondent 6: *Definitely, cutting and grinding stones release dust.*

Researcher: What measures do you have to control dust generation?

Respondent 6: *Installing dust extractors in crushers.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 6: *We rely on both national labor codes and internal policies.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 6: *Yes, but mostly when symptoms arise.*

Researcher: How many times has it been done?

Respondent 6: *Every year, if resources are allowed.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 6: *Based on the Namibian Labour Code provisions.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 6: *Yes, though not all workers attend.*

Researcher: Are all your employees provided with PPE?

Respondent 6: *Yes, even casual workers get PPE.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 6: *No, we ensure PPE is company-issued.*

Researcher: What is the highest education level for your employees?

Respondent 6: *Grade 9 and 10 is common.*

Researcher: Do your employees understand respiratory protection?

Respondent 6: *Some only understand basic PPE use.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 6: *Often see resistance to consistent use.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 6: *Not routine for most workers.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 6: *Better among trained workers.*

<u>Manager Response #7</u>

Researcher: Good afternoon, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 7: *Good afternoon, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 7: Y*es, the conveyor belts and crushers generate dust.*

Researcher: What measures do you have to control dust generation?

Respondent 7: *Covering conveyor belts and minimising drop heights.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 7: *Namibia's Employment Services Act is followed.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 7: *Yes, though follow-up checks are irregular.*

Researcher: How many times has it been done?

Respondent 7: *We try twice per contract cycle.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 7: *We use a checklist-driven SOP system.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 7: Y*es, PPE use training is compulsory.*

Researcher: Are all your employees provided with PPE?

Respondent 7: *Yes, though supply delays occur.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 7: *No, selling PPE is against policy.*

Researcher: What is the highest education level for your employees?

Respondent 7: *Few with vocational certificates.*

Researcher: Do your employees understand respiratory protection?

Respondent 7: *Poor understanding of long-term risks.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 7: *Belief in PPE improving health exists.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 7: *Used properly during inspections.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 7: *Masks are often misused or forgotten.*

<u>**Manager Response #8**</u>

Researcher: Good afternoon, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 8: *Good afternoon, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 8: *Yes, high dust levels are common in our working zones.*

Researcher: What measures do you have to control dust generation?

Respondent 8: *Providing workers with masks and improving ventilation*.

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 8: *General WHO workplace health principles are used.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 8: *Yes, especially after long sick leaves.*

Researcher: How many times is it done?

Respondent 8: *Done at the beginning and midpoint of contracts.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 8: *SOPs from the head office based on industry best practices.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 8: *Yes, but respiratory training is inconsistent.*

Researcher: Are all your employees provided with PPE?

Respondent 8: *Yes, but stockouts happen sometimes.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 8: *No, workers don't pay for safety.*

Researcher: What is the highest education level for your employees?

Respondent 8: *Most with non-accredited schooling*.

Researcher: Do your employees understand respiratory protection?

Respondent 8: *They know about dust but not protection methods.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 8: *Some think masks cause discomfort*.

Researcher: How often do your workers utilise their Protective equipment?

Respondent 8: *Poor adherence outside of checks.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 8: *Improves after disciplinary action.*

Manager Response #9

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 9: *Good morning, ma'am, welcome, please go ahead*.

Researcher: Does your work process produce any kind of Dust?

Respondent 9: *Yes, especially during high-output days.*

Researcher: What measures do you have to control dust generation?

Respondent 9: *Scheduled dust monitoring and control.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 9: *We consult the Ministry of Labour guidelines.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 9: *Yes, mostly for high-risk departments.*

Researcher: How many times is it done?

Respondent 9: *Typically, once unless concerns arise.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 9: *We adapt MSHA-based SOP templates.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 9: *Yes, induction covers it, but practice differs.*

Researcher: Are all your employees provided with PPE?

Respondent 9: *Yes, customised sizes are available.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 9: *No, it is funded via our safety budget.*

Researcher: What is the highest education level for your employees?

Respondent 9: *Limited formal education.*

Researcher: Do your employees understand respiratory protection?

Respondent 9: *Not in detail; many rely on supervision.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 9: *Attitudes depend on peer influence.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 9: *Better in dust-intensive areas.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 9: *Not all see PPE as essential.*

<u>Manager Response #10</u>

Researcher: Good morning, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 10: *Good morning, ma'am, welcome, please go ahead*.

Researcher: Does your work process produce any kind of Dust?

Respondent 10: *Yes, especially during loading operations.*

Researcher: What measures do you have to control dust generation?

Respondent 10: *Suppressing dust using foam agents in specific zones.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 10: *The Mining Safety Manual was provided by our corporate office.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 10: *Yes, but under budget limitations.*

Researcher: How many times is it done?

Respondent 10: *Once a year, as per policy.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 10: *In-house developed SOPs approved by management.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 10: *Yes, we partner with trainers annually*.

Researcher: Are all your employees provided with PPE?

Respondent 10: *Yes, and we keep usage records*.

Researcher: Do you sell the PPE/C to your employers?

Respondent 10: *No, and we ensure timely distribution.*

Researcher: What is the highest education level for your employees?

Respondent 10: *High illiteracy rate in some departments.*

Researcher: Do your employees understand respiratory protection?

Respondent 10: *Awareness exists, but knowledge is weak.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 10: *Positive after safety incidents.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 10: *Irregular usage across shifts.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 10: *Poor use of respiratory gear.*

<u>**Manager Response #11**</u>

Researcher: Good afternoon, sir. I am Saima Shihepo, and I am conducting research with the aim of developing a framework for the protection of quarry and allied workers from occupational respiratory infections in Namibia. I was given permission by the PS of MoHSS and by the Namibia University of Science and Technology to continue with research. Thank you for availing yourself by permitting me to interview you for the next 10- 25 minutes. All information will be treated in the strictest confidence, responses are anonymous, and you are free to withdraw from the study at any time without any implications against you as an individual.

Respondent 11: *Good afternoon, ma'am, welcome, please go ahead.*

Researcher: Does your work process produce any kind of Dust?

Respondent 11: *Yes, there's no way to avoid it in mining work.*

Researcher: What measures do you have to control dust generation?

Respondent 11: *Manual water application during high-dust periods.*

Researcher: What legal document guides you about the protection of workers from occupational respiratory infections?

Respondent 11: *Namibia's Occupational Safety and Health Guidelines.*

Researcher: Do you conduct medical check-ups for your workers?

Respondent 11: *Yes, funded under our wellness programme.*

Researcher: How many times is it done?

Respondent 11: *Every 6 months for certain jobs.*

Researcher: What standard operating procedure guides your protection from occupational injuries?

Respondent 11: *We follow OHSAS guidelines.*

Researcher: Do you provide training to your workers on the use and importance of Personal Protective Equipment (PPE) and respiratory protection?

Respondent 11: *Yes, via safety workshops quarterly.*

Researcher: Are all your employees provided with PPE?

Respondent 11: *Yes, fully funded by the company.*

Researcher: Do you sell the PPE/C to your employers?

Respondent 11: *No, it's included in contract terms.*

Researcher: What is the highest education level for your employees?

Respondent 11: *Some only have primary education.*

Researcher: Do your employees understand respiratory protection?

Respondent 11: *Knowledge varies depending on the department.*

Researcher: How is your employee's attitude towards Personal Protective Equipment?

Respondent 11: *Younger workers show better compliance.*

Researcher: How often do your workers utilise their Protective equipment?

Respondent 11: *Some only wear partial PPE.*

Researcher: Do your workers comply with the use of Protective equipment?

Respondent 11: *Enforcement is still a challenge.*

APPENDIX H: FRAMEWORK EVALUATION CHECKLIST

Framework Title: A FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA

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CO Supervisor: Roswitha Mahalie; rqmahalie@gmail.com; +264 813044166. Faculty of Health, Natural Resources and Applied Sciences; School of Health Sciences, Namibia University of Science and Technology (NUST), Private Bag 13301, Windhoek, Namibia.

Dear Stakeholder,
I, Saima Shihepo, a PhD student at the Namibia University of Science and Technology, School of Health and Applied Sciences, hereby invite you to participate in the evaluation for the development of a Framework titled: A FRAMEWORK FOR THE PROTECTION OF QUARRY AND ALLIED WORKERS FROM OCCUPATIONAL RESPIRATORY INFECTIONS IN NAMIBIA.
Kindly evaluate the developed framework (attached) for the protection of quarry and allied workers from occupational respiratory infection, which is aimed at enhancing the respiratory protection of quarry and allied workers, promoting the implementation of engineering and administrative control, and effectively using PPE/.

Evaluation Questionnaire:

Adopted from Chinn and Kramer (2011: 196-205)

Questionnaire	YES	NO	Comment
Clarity of the framework 1. Do you think the framework is easy to understand?			
2. Are the objectives achievable?			
3. Are the objectives practical?			
The generality of the framework 4. Can this framework be applied in other situations?			
Accessibility of the framework 5. Do you think the framework is very important and significant to the Quarry and Allied workers?			
Significance and usefulness of the framework 6. How relevant is the framework?			
General Comment			

Thank you

ARTICLES

ARTICLE 1

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Full Length Research Paper

Utilising the hierarchical hazard control model to reveal respiratory challenges faced by quarry and allied workers in Erongo, Otjozondjupa and Kunene regions, Namibia: A cross-sectional, quantitative study

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The study examines respiratory protection practices among quarry and allied workers in Namibia, amidst rising concerns over occupational respiratory disorders due to prolonged exposure to respirable dust. Utilising a quantitative cross-sectional design, data were collected from 304 workers across Erongo, Otjozondjupa, and Kunene regions. Findings showed a statistically significant association between employee respiratory protection and employment status ($\chi2(1) = 7.692$, $p = 0.000$), job category ($\chi^2(9) = 37.742$, $p = 0.000$), educational level ($\chi^2(3) = 68.517$, $p = 0.000$) and worksite ($\chi^2(8) = 282.178$, $p = 0.001$). There was a strong positive correlation between employee respiratory protection and worksite ($r=0.7$) at 99% CI (2-tailed) as well as a weak positive association between employee respiratory protection and age ($r=0.142$) at 95% CI). The findings underscore a critical gap in implementing effective engineering controls and training programmes, increasing risk of respiratory illnesses among workers. Recommendations include enhancing educational initiatives on respiratory safety, ensuring compliance with PPE provisions, and conducting regular medical evaluations to safeguard worker health and mitigate the risks associated with dust exposure.

Key words: Hierarchical hazard, respiratory diseases, quarry and allied workers.

INTRODUCTION

Quarry mining, charcoal production and construction are the key industries in which workers are exposed to respirable dust (Szymendera, 2017). In the aforementioned industries, dust particles are generated when sand, gravel, clay, stones, concrete, bricks and quartz are broken, stirred, or otherwise disturbed through cutting, drilling, mixing, blasting, grinding or crushing (Draid et al., 2015). Inhaled dust penetrates deep into the lungs putting the quarry workers at an elevated risk of incurable work-related illness (WRI) particularly respiratory disorders such as lung cancer, pneumoconiosis, asthma, chronic obstructive pulmonary

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disease, silicosis and kidney disease (Wadsworth et al., 2019).

The prevalence of occupational respiratory hazards and mortality is on the increase in Namibia (Nangolo, 2019). The increased risks of adverse respiratory outcomes among charcoal workers are affected by high levels of cumulative dust exposure (Hamatui et al., 2016). In addition, dust was reported as a common physical hazard at the study sites, with some workers reported difficulties breathing in Namibia (Nghitanwa and Zungu, 2017). To curb this respiratory public concern, authorities worldwide, including Namibia, have been developing various respiratory safety measures/techniques to help reduce the huge amount of dust inhaled by employees.

Although several national programmes are implemented in Namibia to prevent the onset of and reduce occupational respiratory conditions, they appear ineffective. There is a lack of a framework that is directed towards establishing a sustainable and integrated system that accommodates occupational respiratory health. Other complementing frameworks such as the Namibian National Health Policy Framework are silent on occupational respiratory conditions.

This framework emphasises clinical and public health respiratory conditions more than the private sector, in which most quarries operate (Amukugo and Nangombe, 2017). In line with this, a need to move towards area-specific approaches such as a framework in occupational respiratory health as an effective and integrated prevention and control program approach to challenge the high prevalence of occupational respiratory conditions in quarry mines. Therefore, this study sought to explore respiratory protection among Namibian quarry and allied workers, as the study enriches previous studies on dust exposure.

MATERIALS AND METHODS

The study used a quantitative cross-sectional design to collect data on respiratory protection among Namibian quarry and allied workers from three regions namely Erongo, Otjozondjupa and Kunene regions as shown in Figure 1. Sample size was enabled through Taro Yamane's formula denoted by n=N/(1+Ne^2) n = sample size while N = population size.

Substituting N with 1112 (which is the target population extracted from the total number of quarry and allied workers as indicated in Table 1) at a 95% confidence level and 5% level of significance, the sample size (n) should be more than 286 hence the study adopted 304 as the sample size for quarry and allied workers. This study used self-administered questionnaires to collect data from the quarry and allied workers, between November and December 2022. Validity was ensured through in-depth scrutiny of standing literature to classify conceptual dimensions and evaluation of the questionnaire by a series of research specialists from the Namibia University of Science and Technology and research supervisors (Leung, 2015). Respondents were granted voluntary participation and provisions to decline or withdraw from the research at any time by informed consent. Signed consent was obtained and respondents were well informed of the study and understood the context to make an informed choice in participating.

Collected data were exported to SPSS version 28, and exploratory data analysis was performed to check for missing data and assess the distribution of numerical variables. Descriptive statistics and precise categorical data were presented as numbers (n) and percentages (%). A Chi-square (χ^2) test was used to determine the association between the level of employee respiratory protection and individual factors significant at p=0.000. A 2-tailed Pearson correlation was done to establish the relationship between selected individual and work-related factors and the level of employee respiratory protection at both 0.01 and 0.05 levels of significance. A linear multiple regression analysis ascertained if selected individual and work-related factors predict the level of employee respiratory protection at 95 CI; p=0.000.

RESULTS

Delineated in Table 1 respondents demographic characteristics, the most dominant age group is 25 to 34 years with 53% (n=161) trailed by 35 to 44 years with 26.3% (n=80). Participants aged 55 to 65 years were least represented with 1% (n=3). There were more males 74.7% (n=227) than females 25.3% (n=77) working in quarries and construction sites.

Most participants were single 89.1% (n=271) compared to those who were married 10.9% (n=33). The majority of the quarry and allied workers attained a secondary school education level of 53% (n=161) followed by primary education of 31.6% (n= 96). Only 6.9% (n=21) reached tertiary level.

Dust exposure at work

The study pursued the proportion of quarry and allied workers exposed to dust at work, as portrayed by the results in Figure 2. As shown in Figure 2: Proportion of quarry and allied workers exposed to workplace dust, the majority of quarry and allied workers (91.1%) were exposed to dust at work while only 8.9% were not.

Protection of quarry and allied workers from respiratory conditions and infections

The current protection of Namibian quarry and allied workers from respiratory conditions and infections is presented using the hierarchical hazard control model. The hierarchy of controls ranks five levels of actions to reduce or remove hazards from the most to least effective. Premised on this study's outcomes, three level action controls for reducing respiratory hazards have been identified from the most to least effective as engineering controls, administration controls and use of PPE/C.

Engineering controls

The use of water mists and sprays (wet drilling) is an

Figure 1. Research study data collection sites.

effective engineering control measure for protecting employees from dust exposure in quarry mines and construction sites. However, as shown in Table 2: *Engineering Controls Used in Protecting Quarry and Allied Workers*, the majority of participants, 87.1% (n = 265), indicated that water sprays were not utilized to reduce the amount of dust emitted into the atmosphere during mining and construction processes.

Furthermore, the application of water mists was an uncommon practice, with nearly all respondents, 98% (n = 298), failing to report its use for protecting quarry and allied workers.

Administrative controls

The application of administrative controls in protecting quarry and allied workers was revealed in the form of educational/training programmes and medical surveillance measures.

Educational /training programmes

Employee education/training is a critical element of any complete protection of employees from workplace hazards as they imparted information on how to protect themselves and co-workers. This article assesses health and safety training among quarry and allied workers in Namibia and reveals the following results in Table 3.

Less than a quarter of the participants 24.3% (n=74) were trained on the importance of PPE/C while the majority 75.7% (n=230) did not receive such training. Subsequently, most quarry and allied workers 60.9% (n=185) did not know any guidelines or company policies on PPE/C while more than a quarter 39.1% (n=119) were knowledgeable.

Medical surveillance measures

This article assesses the existence of a medical surveillance programme as part of a respiratory protection initiative. All the quarry and allied workers (100%) did not undergo pre-employment medical checkups. Upon employment, only 11.8% (n=36) of the workers acknowledged going for periodic medical examinations compared to 88.2% (n=268) who did not. None of the employees requires medical examinations to ensure the worker can use the PPE without risk to their own health.

Association between employee level of respiratory protection with individual and work-related factors

A Chi-square test was performed to ascertain the association between the level of employee respiratory

Table 1. Respondents demographic characteristics.

Demographic variable	Characteristic	(n)	(%)
Age	18-24 years	40	13.2
	25-34 years	161	53
	35-44 years	80	26.3
	45-54 years	20	6.6
	55-65 years	3	1
	Total	304	100
Gender	Male	227	74.7
	Female	77	25.3
	Total	304	100
Marital status	Single	271	89.1
	Married	33	10.9
	Total	304	100
Educational level	None	26	8.6
	Primary level	96	31.6
	Secondary level	161	53.0
	Tertiary level	21	6.9
	Total	304	100.0
Employment status	Full time	280	92.1
	Part-time	24	7.9
	Total	304	100
Working experience	Less than a year	34	11.2
	1-3 years	122	40.1
	4-7 years	113	37.2
	7-10 years	27	8.9
	More than 10 years	8	2.6
	Total	304	100

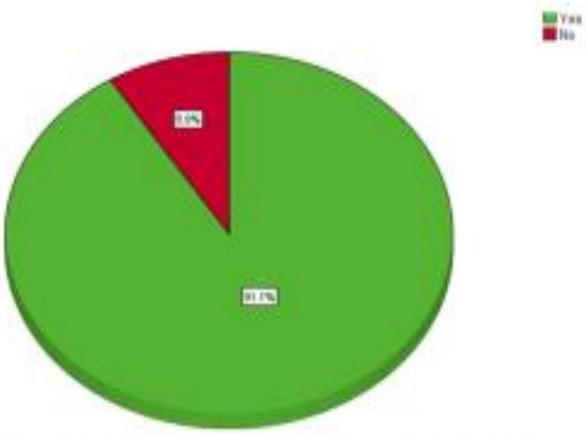

Figure 2. Proportion of quarry and allied workers exposed to workplace dust.

Table 2. Engineering controls used in protecting quarry and allied workers.

Engineering controls	Yes		No	
	(n)	(%)	(n)	(%)
Water sprays (wet drilling)	39	12.9	265	87.1
Water mists	6	2	298	98

Table 3. Employee educational awareness/training.

Question	Response	(n)	(%)
Are you aware of any health and safety guidelines or company policies	Yes	119	39.1
	No	185	60.9
	Total	304	100
Are you trained on the importance, use and care of PPE/C	Yes	74	24.3
	No	230	75.7
	Total	304	100

Table 4. The association between individual and work-related factors and employee respiratory protection.

Variable	Value	df	Asymptotic Significance (2-sided)
Age	5.618	3	0.006
Gender	0.053	1	0.818
Marital status	0.338	1	0.561
Employment status	7.592	1	0.000
Working experience	12.275	4	0.015
Job category	37.742	9	0.000
Frequency of PPE/C utilisation	0.708	1	0.004
Educational level	68.517	3	0.000
Worksite	282.178	8	0.000

protection and the following individual factors, age, gender, marital status, employment status, working experience, job category, frequency of PPE/C utilisation, and educational level work site.

As shown in Table 4: The association between individual and work-related factors and employee respiratory protection, the Pearson Chi-Square test result portrays a statistically significant association between employee respiratory protection and employment status at $\chi^2(1) = 7.592$, $p = 0.000$; employee respiratory protection and job category at $\chi^2(9) = 37.742$, $p = 0.000$; employee respiratory protection and educational level at $\chi^2(3) = 68.517$, $p = 0.000$; employee respiratory protection and worksite at $\chi^2(8) = 282.178$, $p = 0.000$. However, there was no statistically significant relationship between employee respiratory protection and age at $\chi^2(3) = 5.618$, $p = 0.006$, employee respiratory protection and gender at $\chi^2(1) = 0.053$, $p = 0.818$, employee respiratory protection and working experience at $\chi^2(4) = 12.275$, $p = 0.015$.

Correlation of individual and work-related factors with the level of employee respiratory protection

A pearson correlation was performed to establish the relationship between selected individual and work-related factors (work site, age, gender, marital status, religion, level of education, employment status, working experience, job category) and the level of employee respiratory protection as indicated in Table 5: Individual and work-related factors correlation with the level of employee respiratory protection.

There was a strong positive correlation between employee respiratory protection and worksite (r=0.7) at 99% CI (2-tailed) as well as a weak positive association

Table 5. Individual and work-related factors correlation with the level of employee respiratory protection.

Correlation variable	Pearson correlation
Level of employee respiratory protection and worksite	0.700**
Level of employee respiratory protection and age	0.142*
Level of employee respiratory protection and gender	0.013
Level of employee respiratory protection and marital status	-0.033
Level of employee respiratory protection and employment status	0.057
Level of employee respiratory protection and working experience	0.036
Level of employee respiratory protection and job category	0.331**
Level of employee respiratory protection and training	-0.841*
Level of employee respiratory protection and educational level	-0.424**

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

Table 6. Model summary analysis of the level of employee respiratory protection and selected individual and work-related factors.

R	R square	Adjusted R square	Std. error of the estimate	R square change	Change statistics			
					F change	df1	df2	Sig. F change
0.72	0.518	0.501	0.285	0.518	31.467	10	293	0.000

Predictors: (Constant), work site, age, gender, marital status, religion, level of education, employment status, working experience, job category.

between employee respiratory protection and age (r=0.142) at 95% CI.

The level of employee respiratory protection showed a positive weak correlation with job category (r=0.331) at 99% CI, a strong positive relationship with training (r=0.841) at 95% CI and a moderately weak association with the level of education (r=0.424) at 99% CI. There was no significant correlation between the level of employee respiratory protection and gender (r=0.013); with employment status (r=-0.057), marital status (r=0.033) and working experience (r=0.036).

Multiple regression analysis of the level of employee respiratory protection and selected individual and work-related factors

A standard regression analysis was conducted to assess selected individual and work-related factors as predictors of employee respiratory protection levels. Table 6: Model Summary Analysis of Employee Respiratory Protection Levels and Selected Individual and Work-Related Factors provide an overview of the results.

The prediction model summary was statistically significant, F (10, 293) = 31.467, p = 0.000 as more than half (52%) of the selected individual factors accounted for the level of employee respiratory protection (R^2 = 0.501, Adjusted R^2 = 0.518). There was a medium-high degree of correlation denoted by R=0.72. These findings imply that selected individual and work-related factors highly influenced the level of employee respiratory protection.

DISCUSSION

This study highlights the inability of quarry mines and construction employers to implement feasible respirable dust engineering controls, such as water mists and sprays. According to Gürcanl et al. (2015), respirable dust engineering controls are designed to eliminate or mitigate hazards at the source by suppressing, diluting, or redirecting dust generated during mining, construction, and related activities. These controls include proper ventilation systems, the use of water sprays and mists (wetting agents), and the installation of control booths or environmental cabs to enclose equipment operators (NIOSH, 2021).

The findings indicate that Namibian quarry and allied workers lack access to engineering controls to reduce their exposure to respirable dust. You et al. (2019) argue that engineering controls provide more consistent and reliable protection than other interventions, as their effectiveness does not rely on individual performance, supervision, or intervention. Additionally, there is a lack of administrative controls, such as educational and training programs, among Namibian quarry and allied workers. According to Zhou et al. (2018), administrative controls enhance workplace safety culture by providing guidance and procedures that demonstrate the company's commitment to safety. In the context of protecting quarry

Table 2. Engineering controls used in protecting quarry and allied workers.

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The absence of sufficient educational and training programs leaves employees with knowledge gaps regarding respiratory protection, reducing their ability to cooperate with and actively participate in precautionary safety measures.

This lackluster approach to training increases the risk of occupational lung diseases and fosters negative attitudes, inadequate knowledge, and poor practices regarding respiratory protective equipment. Training programs, which involve interaction with professionals skilled in the proper use of PPE, help overcome employee resistance and promote correct PPE usage (NIOSH, 2021). Furthermore, educational and training programs on safety precautions, particularly the correct use of PPE, have been shown to effectively increase knowledge and prevent respiratory symptoms and diseases associated with quarrying, construction, and related exposures (Alemu et al., 2020).

The study results revealed that none of the quarry and allied workers underwent mandatory initial medical examinations. Health surveillance for respiratory protection involves repeated medical assessments and the collection of information, including medical history tracking, regular physical examinations, chest X-rays, and lung function tests (Almberg et al., 2020). According to NIOSH (2019b), initial examinations are critical for the early detection of respirable dust-related illnesses and conditions that could increase susceptibility to the toxic effects of respirable dust. The absence of initial examinations leaves Namibian quarry and allied workers poorly protected from respiratory conditions, increasing the risk of undetected impairments and delayed intervention (Chen et al., 2022). Without these examinations, early detection and treatment of respiratory illnesses are hindered, allowing for greater disease progression and worsening health outcomes.

The findings also highlighted that most quarry and allied workers did not undergo periodic medical examinations. Without an initial medical baseline and subsequent periodic assessments, it becomes challenging to track health changes and effectively protect workers from respirable dust-related illnesses (Coffman et al., 2021). Medical evaluations, including reviews of work and medical histories and physical examinations, are essential for ensuring workers' ability to use respirators. These evaluations account for the potential physical and psychological burden of respirator use, which can vary depending on the type of respirator, job requirements, and workplace conditions (Lancet, 2019).

Furthermore, the study noted that many quarry and allied workers were not provided with personal protective equipment and clothing (PPE/C), despite it being a mandatory obligation under the Namibian Labour Act. The lack of PPE/C significantly jeopardizes protection from respiratory conditions. PPE is considered the last line of defense when engineering and administrative controls are not feasible or insufficient (Alemu et al., 2020). Among those provided with PPE/C, the majority received it free of charge. This aligns with the requirement that employers must provide NIOSH-approved respirators, suitable for their intended purpose, at no cost to workers in mining and construction industries to effectively protect them from respirable dust (Alemu et al., 2020). Providing respirators at no cost reduces workers' susceptibility to respirable dust and promotes safer working environments.

The use of PPE/C among quarry and allied workers was inconsistent, with most individuals only occasionally using it. These findings indicate a lack of adherence to PPE/C usage among Namibian quarry and allied workers, making them susceptible to respiratory conditions and related illnesses. According to Ashley and O'Connor (2017), PPE serves as a supplementary control by providing direct protection to workers. However, compliance with respiratory protection guidelines is troublingly low in industries such as construction and mining (Dhatrak and Nandi, 2020). Conversely, Yarpuz-Bozdogan (2018) found that PPE usage reduced the intermediate risk of respiratory injury by 44%, the maximum risk by 32%, and increased the likelihood of no respiratory effects by 24%.

The findings suggest that the type of PPE/C provided to Namibian quarry and allied workers is skewed towards general body protection (e.g., overalls) rather than respiratory protection, which is critical given the nature of their work.

The limited use of respirators significantly reduces the level of protection, increasing the risk of adverse respiratory health effects associated with respirable dust exposure. NIOSH (2019a) recommends the use of respirators as an interim measure when engineering and administrative controls fail to maintain worker exposure to respirable dust at or below the proposed permissible exposure limit (PEL). Contrary to the findings of the current article, the use of respirators as an interim measure in maintaining worker exposure to respirable dust at or below the proposed PEL is recommended (NIOSH, 2019a).

Evidence from the study revealed that disposable N95 respirators and surgical masks were used against respirable dust exposure. However, Lee et al. (2005) argue that different respirators offer varying levels of protection, making it essential to select the appropriate type to guard against specific dust PEL exposures. Disposable N95 respirators are effective against larger dust particles, but quarry mines and construction sites often generate smaller, finer particles (Zgambo, 2015). In contrast, half-facepiece respirators protect against smaller dust particles, while full-facepiece respirators provide both eye and respiratory protection. Surgical masks, on the other hand, are the least protective, with a filtration efficiency ranging from 25.7 to 61.5%, whereas half-facepiece P100 respirators offer the highest filtration efficiency, between 96.5 and 98.9% (Sapbamrer et al., 2021).

The continued exposure of quarry and allied workers to respirable dust underscores the importance of using filtering facepiece respirators (FFRs) in such environments (Lee et al., 2005). Ensuring access to appropriate respirators tailored to the specific dust exposure risks is essential for improving worker safety and reducing health risks.

The findings also revealed that none of the employees provided with respirators underwent fit testing. In the complete absence of respirator fit testing, it is evident that quarry and allied workers in Namibia are not adequately protected against exposure to respirable dust and contaminated ambient air. Research supports the use of respirators for lung protection when working with hazardous occupational inhalants, emphasizing that fit testing is essential to ensure maximum respiratory protection (National Center for Environmental Health, 2014). Respirator fit testing verifies the correct mask size and ensures there are no air leaks, thereby protecting individuals from hazardous inhalants (Ashley and O'Connor, 2017). Before using any respirator face piece, employees must be fit-tested with the same make, model, style, and size of the respirator they will use.

The study also found that less than half of the quarry and allied workers were inadequately protected by respirators due to excessive facial hair. Facial hair, including beards and wide sideburns, can interfere with the tight seal required for effective respirator performance. If a proper seal is not maintained between the face piece and the worker's face, contaminated air can be drawn into the respirator and inhaled (Rengasamy et al., 2017). Research indicates that facial hair has a detrimental effect on respirator performance, and workers with excessive facial hair cannot achieve the same level of protection as clean-shaven individuals (Jacobsen et al., 2021). OSHA concludes that poorly fitting respirators expose workers to contaminants and recommends an effective fit-testing protocol to determine the most appropriate respirator face piece for each employee (Mornyer, 2016).

The regression model in the study showed that factors such as education level, age, work experience, and worksite risk perception significantly influence the level of respiratory protection among quarry and allied workers. Studies across various occupations have identified these individual factors as key determinants of respiratory protection (Z'gambo, 2015). Education level, in particular, greatly impacts respiratory protection. Lower educational levels, such as primary education or below, as noted among most Namibian quarry and allied workers, correlate with reduced respiratory protection due to difficulties in understanding and applying respiratory protection information.

A study by Almberg et al. (2020) found that education level significantly influenced respiratory protection, with individuals lacking formal education being less likely to protect themselves from respiratory hazards. However, the difference in protection levels between those with basic education and higher education was not statistically significant.

Research by Jacobsen et al. (2021) further indicated that individuals without formal education often neglected proper PPE usage, leaving them more vulnerable to respiratory hazards.

Worksite risk perception has been shown to influence the respiratory protection practices of quarry and allied workers. According to the protection motivation theory, risk perception and the use of PPE increase when workers perceive a tangible reason for concern. In many cases, employees become more vigilant about protecting themselves from respiratory conditions after experiencing or being affected by a respiratory illness.

Sehsah et al. (2020) found that workers who had previously experienced an accident or incident felt less safe and were more aware of risks than those who had not, making them more likely to take protective measures. Similarly, when workers are made aware of workplace hazards, they are more inclined to use PPE to shield themselves from exposure to those hazards. Conversely, if workers are provided with PPE but are not adequately informed about its purpose or proper use, it is unlikely that they will utilize the equipment effectively.

Kumar et al. (2016) emphasize the importance of ensuring that workers understand the hazards and risks associated with their tasks and are knowledgeable about how to protect themselves. Such knowledge promotes the proper use of PPE and reduces exposure to workplace hazards.

Conclusion

The study revealed that quarry operators and construction companies were unable to effectively implement engineering controls, such as sprays and water mists, to reduce workers' exposure to respirable dust. Additionally, most allied and quarry workers did not undergo the mandatory medical examinations, contradicting NIOSH's recommendation that construction and mining companies provide such examinations to new employees.

Despite the mandate in the Labour Act of Namibia requiring the provision of protective equipment, most workers were not supplied with the necessary PPE. Without appropriate equipment, workers are at an increased risk of developing respiratory conditions detrimental to their health. The study found that the type of PPE provided to workers in Namibia is predominantly geared toward general body protection, rather than respiratory protection. The limited use of respirators among workers significantly reduces their level of protection, increasing the risk of adverse health effects due to dust exposure.

Furthermore, the study highlighted that none of the employees had undergone a fit test for respirators. This lack of fit testing underscores the inadequate protection against dust and air contamination for allied and quarry workers in Namibia. The findings also indicated that less than half of the employees had adequate respiratory protection due to issues related to facial hair, which compromises the proper seal of respirators.

The study supports the protection motivation theory, which asserts that workers are more likely to use protective equipment when they perceive a concern for their safety. When workers are aware of workplace hazards and the associated risks, they are more inclined to adopt protective measures, including the use of PPE, to safeguard their health.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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ARTICLE 2

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The Implementation of the Hierarchical Hazard Control Model to Assess the Respiratory Protection of Quarry and Allied Workers in Namibia

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ABSTRACT

The increased risks of adverse respiratory outcomes among quarry and allied workers are affected by high levels of cumulative dust exposure, which is a significant concern in the occupational health sector in developing countries, like Namibia. The study examines respiratory protection practices among quarry and allied workers in Namibia, amidst rising concerns over occupational respiratory disorders due to prolonged exposure to respirable dust. Using the Hierarchical Hazard Control Model, the study assessed the Engineering Controls, Administrative Controls, Educational/Training Programmes, and Medical Surveillance Measures in dust controls for 304 quarry and allied workers in the Erongo, Otjozondjupa, and Kunene regions. This study used self-administered questionnaires to collect data from the quarry and allied workers, between November and December 2022. A Chi-square (χ^2) test was used to determine the association between the level of employee respiratory protection and individual factors significant at p=0.000. Findings showed a statistically significant association between employee respiratory protection and employment status ($\chi2(1) = 7.592$, $p = 0.000$), job category ($\chi^2(9) = 37.742$, $p = 0.000$), educational level ($\chi^2(3) = 68.517$, $p = 0.000$) and worksite ($\chi^2(8) = 282.178$, $p = 0.001$). A strong positive correlation between worksite and respiratory protection ($r=0.7$, $p<0.01$), negative correlation between worksite protection and education/training programs ($r=0.841$, $p<0.05$) was found. The findings underscore a critical gap in implementing effective engineering controls and training programs, increasing

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the risk of respiratory illnesses among workers. In conclusion, the study revealed that quarry and allied workers could not effectively implement engineering controls to reduce workers' exposure to respirable dust due to the lack of an occupational respiratory health framework, safety regulations and enforcement, and education and training. The study also provided evidence that most allied and quarry workers did not undergo the mandatory medical examination, as a request of limited hazard control measures. Recommendations include a need for an occupational respiratory health framework for quarry and allied workers to ensure occupational respiratory health.
Effective government policy that will enhance occupational safety and health in mining and quarrying is necessary for accident prevention in Namibia.

Keywords: Hierarchical hazard; respiratory diseases; quarry and allied workers; respiratory protection; occupational safety.

1. INTRODUCTION

Quarry mining in Namibia is an important business sector as it employs a significant population as well as contributing to the country's Gross Domestic Product (GDP). The mining and quarrying sector contributes 11.7 percent to the Namibian GDP (Nambinga & Mubita, 2022). Apart from satisfying the ever-growing needs of a rapidly growing population for infrastructural development and urbanization, quarrying activities have helped to provide direct and indirect jobs for many people living in host communities (Ogbonnaya et al., 2016). Quarry mining, charcoal production, and construction are the key industries in which workers are exposed to respirable dust (Szymendera, 2017). In the aforementioned industries, dust particles are generated when sand, gravel, clay, stones, concrete, bricks, and quartz are broken, stirred, or otherwise disturbed through cutting, drilling, mixing, blasting, grinding, or crushing (Draid *et al.,* 2015). Inhaled dust penetrates deep into the lungs, putting the quarry workers at an elevated risk of incurable work-related illness (WRI), particularly respiratory disorders such as lung cancer, pneumoconiosis, asthma, chronic obstructive pulmonary disease, silicosis, and kidney disease (Wadsworth *et al.,* 2019). A high prevalence of silicosis, asthma, and adverse respiratory symptoms like cough, chest pain, and dyspnea has been reported among workers engaged in quarrying. Additionally, quarrying also poses a danger to workers due to injuries caused by rocks falling on the workers, accidents during the use of machinery along with eye problems (Nemer et al., 2020). The prevalence of occupational respiratory hazards and mortality is on the increase in Namibia (Nangolo, 2019). The increased risks of adverse respiratory outcomes among charcoal workers are affected by high levels of cumulative dust exposure (Hamatui *et al.,* 2016). In addition, dust was reported as a common physical hazard at the study sites, with some workers reporting difficulties breathing in Namibia (Nghitanwa & Zungu, 2017). To curb this public respiratory concern, authorities worldwide, including Namibia, have been developing various respiratory safety measures/techniques to help reduce the huge amount of dust inhaled by employees (Shihepo et al., 2024).

Kumar, Gupta, Agarwal, and Singh (2016) acknowledge that Mining and construction industry workers face occupational hazards due to a lack of legal protection and unorganized structures. According to (Geng & Saleh, 2015), effective government policy and safety regulations enhance occupational safety and health in mining and quarrying and are necessary for accident prevention. However, Sanmiquel et al. (2015) argued that despite new laws being introduced to enhance occupational safety, accidents of different nature still occur, including fatal accidents. A Research study conducted by Amukugo & Nangombe (2017) states how a policy framework, such as the Namibian National Health policy framework, outlines the guidelines of actions of the public servants. Namibia lacks an occupational respiratory health framework for quarry and allied workers to ensure occupational respiratory health.

In addition, the Namibian Labour Act makes provision for general protection for workers, but the enforcement of worker protection is inadequate. Thus, the need for training and awareness amongst quarry and allied workers regarding respiratory hazards and the use of PPE which is also lacking in quarry mines in Namibia. The lack of an occupational respiratory health framework, safety regulations and enforcement and education and training may lead to increased injury rates (Long et al., 2015).

Although several national programs are implemented in Namibia to prevent the onset of and reduce occupational respiratory conditions, they appear ineffective. There is a lack of a framework that is directed towards establishing a sustainable and integrated system that accommodates occupational respiratory health. Other complementing frameworks, such as the Namibian National Health Policy Framework, are silent on occupational respiratory conditions. This framework emphasises clinical and public health respiratory conditions more than the private sector, in which most quarries operate (Amukugo & Nangombe, 2017). In line with this, a need to move towards area-specific approaches, such as a framework in occupational respiratory health, as an effective and integrated prevention and control program approach to challenge the high prevalence of occupational respiratory conditions in quarry mines. Therefore, this study sought to explore respiratory protection among Namibian quarry and allied workers, as the study enriches previous studies on dust exposure.

2. MATERIALS AND METHODS

The study used a quantitative cross-sectional design to collect data on respiratory protection among Namibian quarry and allied workers from three regions, namely Erongo, Otjozondjupa and Kunene regions, as shown in Fig. 1 (Shihepo et al., 2024). The sample size was enabled through Taro Yamane's formula, denoted by $n=N/(1+Ne^2)$ n = sample size, while N = population size. Substituting N with 1112 (which is the target population extracted from the total number of quarry and allied workers as indicated in Table 1) at a 95% confidence level and 5% level of significance, the sample size (n) should be more than 286 hence the study adopted 304 as the sample size for quarry and allied workers (Shihepo et al., 2024).

To ensure reliability, the questionnaire was subjected to a pilot test to assess the relevance, sensitivity, and acceptability of the questions. The results validated the questionnaire's consistency and accuracy, determining its effectiveness and allowing for modifications to suit the study's objectives, thus ensuring its validity. A pilot test was conducted in Otavi, with 5% of the study sample being pretested with the questionnaire and the interview guide. The pilot test was carried out on quarry and allied workers from Sargberg Charcoal in August 2022, thus participants with characteristics similar to those selected for the main study. The pilot study enabled the investigator to develop participant approach skills, which was an effective way of recruiting participants for the main study.

This study used self-administered questionnaires to collect data from the quarry and allied workers, between November and December 2022 (Shihepo et al., 2024). Validity was ensured through in-depth scrutiny of the standing literature to classify conceptual dimensions and evaluation of the questionnaire by a series of research specialists from the Namibia University of Science and Technology and research supervisors (Leung, 2015). Research seminars in article writing at NUST/DRIP contributed to the credibility of this study.

The study involved participants who were given the option to decline or withdraw from the research through informed consent, ensuring they understood the importance of making an informed decision before participating in the study. Confidentiality and anonymity were ensured by not revealing the source of data and omitting identifying information. All data was held strictly confidential, as the researcher was the only one who knew the source or origin of the data. Subsequently, the data was kept in a password-secured computer only accessible by the researcher. It was explained to the participants (managerial staff, quarry workers, and allied workers) that they were not liable for punishment, victimisation or mistreatment following their involvement or not in the study. In this study, the participants had no direct benefits from their participation; however, there are indirect benefits from the implementation of recommendations as per the study findings. The researcher obtained ethical clearance and approval to conduct the study from the Namibia University of Science and Technology, with ethical clearance from the Ministry of Health and Social Services, and from the selected participating companies in the study.

Collected data were exported to SPSS version 28, and exploratory data analysis was performed to check for missing data and assess the distribution of numerical variables. Descriptive statistics and precise categorical data were presented as numbers (*n*) and percentages (%) (Shihepo et al., 2024). A Chi-square (χ^2) test was used to determine the association between the level of employee respiratory protection and individual factors significant at p=0.000. A 2-tailed Pearson correlation was done to establish the relationship between selected individual and work-related factors and the level of employee respiratory protection at both 0.01 and 0.05 levels of significance. A linear multiple regression analysis ascertained if selected individual and work-related factors predict the level of employee respiratory protection at 95 CI; p=0.000 (Shihepo et al., 2024).

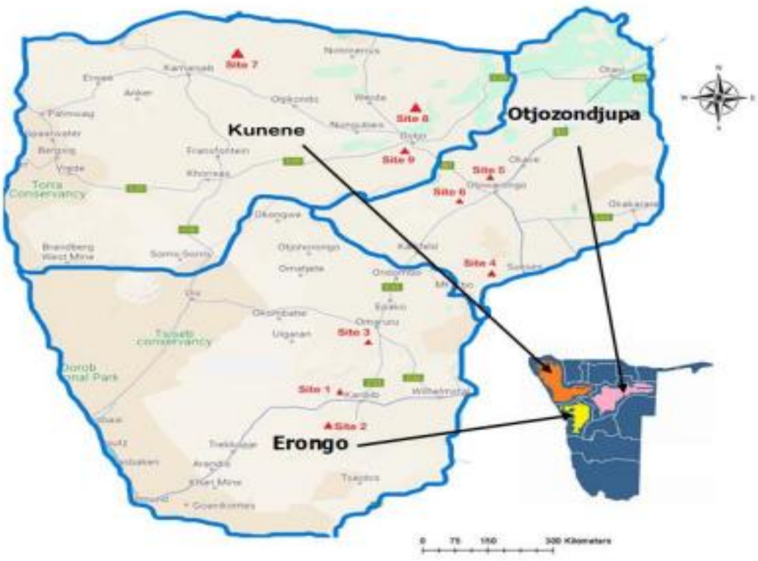

Fig. 1. Research study data collection sites

3. RESULTS

Delineated in Table 1, respondents' demographic characteristics, the most dominant age group is 25-34 years with 53% (n=161), trailed by 35-44 years with 26.3% (n=80) (Shihepo et al., 2024). Participants aged 55-65 years were the least represented with 1% (n=3). There were more males, 74.7% (n=227), than females, 25.3% (n=77), working in quarries and construction sites. Most participants were single, 89.1% (n=271), compared to those who were married, 10.9% (n=33).

The majority of the quarry and allied workers attained a secondary school education level of 53% (n=161), followed by primary education of 31.6% (n=96). Only 6.9% (n=21) reached the tertiary level (Shihepo et al., 2024).

Almost all 92.1% (n=280) quarry and allied workers were fully employed, whereas only 7.9% (n=24) worked on a part-time basis. The bulk of the participants, 27% (n=134), worked under stone blasting, followed by bagging 18.8% and loading 13.2%. Few individuals, 3% of the respondents, worked as builders, and 4.3% worked in stone collection and grinding as well as polishing. The majority of quarry and allied workers, 40.1% (n=122), worked for 1-3 years, followed by those working for 4-7 years, 37.2% (n=113). Only 2.6% (n=8) worked for more than 10 years.

Table 1. Respondents' demographic characteristics

Demographic Variable	Characteristic	Frequency (n)	Percent (%)
Age	18-24 years	40	13.2
	25-34 years	161	53
	35-44 years	80	26.3
	45-54 years	20	6.6
	55-65 years	3	1
	Total	304	100
Gender	Male	227	74.7
	Female	77	25.3
	Total	304	100
Marital Status	Single	271	89.1
	Married	33	10.9
	Total	304	100
Educational Level	None	26	8.6
	Primary level	96	31.6
	Secondary level	161	53.0
	Tertiary level	21	6.9
	Total	304	100.0
Employment Status	Full time	280	92.1
	Part-time	24	7.9
	Total	304	100
Working Experience	Less than a year	34	11.2
	1-3 years	122	40.1
	4-7 years	113	37.2
	7-10 years	27	8.9
	More than 10 years	8	2.6
	Total	304	100

3.1 Dust Exposure at Work

The study pursued the proportion of quarry and allied workers exposed to dust at work, as portrayed by the results in Fig. 2 (Shihepo et al., 2024).

As shown in Fig. 2: Proportion of quarry and allied workers exposed to workplace dust, the majority of quarry and allied workers (91.1%) were exposed to dust at work, while only 8.9% were not (Shihepo et al., 2024).

4. PROTECTION OF QUARRY AND ALLIED WORKERS FROM RESPIRATORY CONDITIONS AND INFECTIONS

The current protection of Namibian quarry and allied workers from respiratory conditions and infections is presented using the hierarchical hazard control model. The hierarchy of controls ranks (5) five levels of actions to reduce or remove hazards from the most to least effective (Shihepo et al., 2024). Premised on this study's outcomes, three (3) level action controls for reducing respiratory hazards have been identified from the most to least effective as engineering controls, administration controls and use of PPE/C.

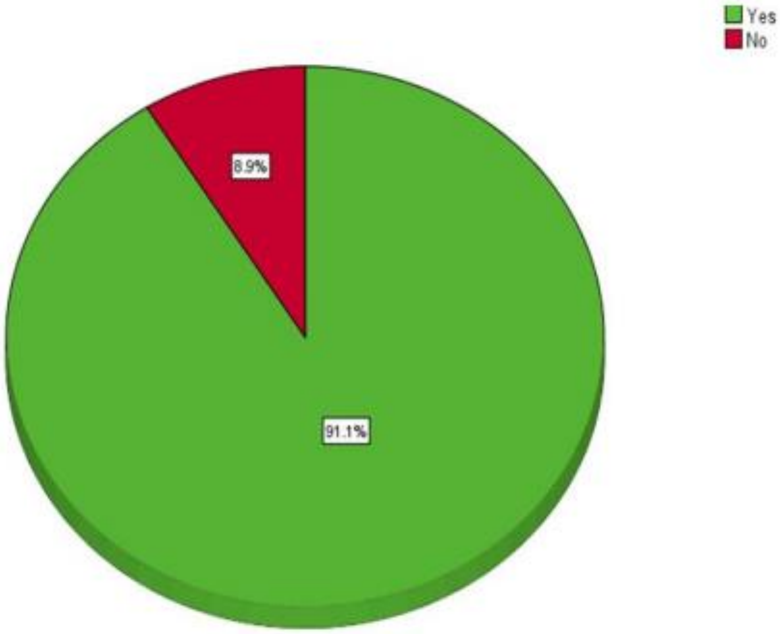

Fig. 2. Proportion of quarry and allied workers exposed to workplace dust

4.1 Engineering Controls

The use of water mists and sprays (wet drilling) is an effective engineering control measure for the protection of employees exposed to dust in quarry mines and construction sites. As shown in Table 2: Engineering controls used in protecting quarry and allied workers below, majority of the participants 87.1% (n=265), indicated that water sprays were not used in reducing the amount of dust emitted in the atmosphere as a result of the mining and construction processes (Shihepo et al., 2024). The application of water mists was not a common practice in protecting quarry and allied workers, as almost all the respondents 98% (n=298), failed to acknowledge.

4.2 Administrative Controls

The application of administrative controls in protecting quarry and allied workers was revealed in the form of educational/training programs and medical surveillance measures (Shihepo et al., 2024).

Table 2. Engineering controls used in protecting quarry and allied workers

	Yes		No	
	Frequency (n)	**Percentage (%)**	**Frequency (n)**	**Percentage (%)**
Water Sprays (wet drilling)	39	12.9	265	87.1
Water Mists	6	2	298	98

Table 3. Employee educational awareness/training

Question	Response	Frequency(n)	Percent (%)
Are you aware of any health and safety guidelines or company policies	Yes	119	39.1
	No	185	60.9
	Total	304	100
Are you trained on the importance, use and care of PPE/C	Yes	74	24.3
	No	230	75.7
	Total	304	100

4.3 Educational /Training Programmes

Employee education/training is a critical element of any complete protection of employees from workplace hazards, as it imparts information on how to protect themselves and co-workers. This article assesses health and safety training among quarry and allied workers in Namibia and reveals the following results in Table 3: Employee educational awareness/training (Shihepo et al., 2024).

Less than a quarter of the participants, 24.3% (n=74), were trained on the importance of PPE/C, while the majority, 75.7% (n=230), did not receive such training. Subsequently, most quarry and allied workers, 60.9% (n=185), did not know any guidelines or company policies on PPE/C, while more than a quarter 39.1% (n=119) were knowledgeable.

4.4 Medical Surveillance Measures

This article assesses the existence of a medical surveillance programme as part of a respiratory protection initiative. All the quarry and allied workers (100%) did not undergo pre-employment medical checkups (Shihepo et al., 2024). Upon employment, only 11.8% (n=36) of the workers acknowledged going for periodic medical examinations compared to 88.2% (n=268) who did not. None of the employees requires medical examinations to ensure the worker can use the PPE without risk to their own health.

4.5 Association between Employee Level of Respiratory Protection with Individual and Work-Related Factors

A Chi-square test was performed to ascertain the association between the level of employee respiratory protection and the following individual factors: age, gender, marital status, employment status, working experience, job category, frequency of PPE/C utilisation, and educational level work site.

Table 4. The association between individual and work-related factors and employee respiratory protection

	Value	df	Asymptotic Significance (2-sided)
Age	5.618	3	0.006
Gender	0.053	1	0.818
Marital status	0.338	1	0.561
Employment status	7.592	1	0.000
Working experience	12.275	4	0.015
Job category	37.742	9	0.000
Frequency of PPE/C utilisation	0.708	1	0.004
Educational level	68.517	3	0.000
Worksite	282.178	8	0.000

As shown in Table 4: The association between individual and work-related factors and employee respiratory protection, the Pearson Chi-Square test result portrays a statistically significant association between employee respiratory protection and employment status at $\chi^2(1) = 7.592$, $p = 0.000$; employee respiratory protection and job category at $\chi^2(9) = 37.742$, $p = 0.000$; employee respiratory protection and educational level at $\chi^2(3) = 68.517$, $p = 0.000$; employee respiratory protection and worksite at $\chi^2(8) = 282.178$, $p = 0.000$ (Shihepo et al., 2024). However, there was no statistically significant relationship between employee respiratory protection and age at $\chi^2(3) = 5.618$, $p = 0.006$, employee respiratory protection and gender at $\chi^2(1) = 0.053$, $p = 0.818$, employee respiratory protection and working experience at $\chi^2(4) = 12.275$, $p = 0.015$.

4.6 Correlation of Individual and Work-Related Factors with the Level of Employee Respiratory Protection

A Pearson correlation was performed to establish the relationship between selected individual and work-related factors (work site, age, gender, marital status, religion, level of education, employment status, working experience, job category) and the level of employee respiratory protection as indicated in Table 5: Individual and work-related factors correlation with the level of employee respiratory protection (Shihepo et al., 2024).

Table 5. Individual and work-related factors correlate with the level of employee respiratory protection

Correlation variables	Pearson Correlation
Level of employee respiratory protection and worksite	.700**
Level of employee respiratory protection and age	.142*
Level of employee respiratory protection and gender	0.013
Level of employee respiratory protection and marital status	-0.033
Level of employee respiratory protection and employment status	0.057
Level of employee respiratory protection and working experience	0.036
Level of employee respiratory protection and job category	.331**
Level of employee respiratory protection and training	-.841*
Level of employee respiratory protection and educational level	-.424**

**Correlation is significant at the 0.01 level (2-tailed).; *Correlation is significant at the 0.05 level (2-tailed).

There was a strong positive correlation between employee respiratory protection and worksite (r=0.7) at 99% CI (2-tailed) as well as a weak positive association between employee respiratory protection and age (r=0.142) at 95% CI. The level of employee respiratory protection showed a positive weak correlation with job category (r=0.331) at 99% CI, a strong positive relationship with training (r=0.841) at 95% CI, and a moderately weak association with the level of education (r=0.424) at 99% CI (Shihepo et al., 2024). There was no significant correlation between the level of employee respiratory protection and gender (r=0.013) employment status (r=-0.057), marital status (r=0.033), and working experience (r=0.036).

4.7 Multiple Regression Analysis of the Level of Employee Respiratory Protection and Selected Individual and Work-Related Factors

Selected individual and work factors were assessed in a standard regression analysis to predict the level of employee respiratory protection. Table 6: Model Summary analysis of the level of employee respiratory protection and selected individual and work-related factors provides an overview of the model summary analysis (Shihepo et al., 2024).

Table 6. Model Summary analysis of the level of employee respiratory protection and selected individual and work-related factors

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
					F Change	df1	df2	
0.72	0.518	0.501	0.285	0.518	31.467	10	293	0.000

Predictors: (Constant), work site, age, gender, marital status, religion, level of education, employment status, working experience, job category.

The prediction model summary was statistically significant, F (10, 293) = 31.467, p = 0.000, as more than half (52%) of the selected individual factors accounted for the level of employee respiratory protection (R^2 = 0.501, Adjusted R^2 = 0.518). There was a medium-high degree of correlation denoted by R=0.72 (Shihepo et al., 2024). These findings imply that selected individual and work-related factors highly influenced the level of employee respiratory protection.

5. DISCUSSION

This study revealed the inability of quarry mines and construction employers to apply feasible respirable dust engineering controls in the form of water mists and sprays. According to Gürcanl, Baradan and Uzun (2015), respirable dust engineering controls are designed to remove or reduce the hazard at the source, meaning suppressing, diluting, or diverting dust generated by mining, construction and associated activities. Respirable dust engineering controls include proper ventilation systems, the use of water sprays, water mist (wetting agents) and control booths or environmental cabs to enclose equipment operators (National Institute for Occupational Safety and Health, 2021). These findings entail that Namibian quarry and allied workers have no engineering controls in place to reduce their exposure to respirable dust (Shihepo et al., 2024). You *et al.* (2019) argue that engineering controls provide more consistent and reliable protection than other interventions because the controls are not dependent on an individual's performance, supervision or intervention to function as intended.

There is a lack of administrative controls such as educational/training programmes, among Namibian quarry and allied workers. According to Zhou *et* *al.* (2014), administrative controls provide additional guidance and procedures, demonstrating the company's commitment to safety and enhancing the overall safety culture of the workplace. In protecting quarry and allied workers, administrative controls come in the form of educational programmes and medical surveillance. With insufficient educational/training programmes, employees are prone to developing knowledge gaps on respiratory protection, making it difficult for them to cooperate and actively participate in precautionary safety and protection measures. The luck-lustre of training entails that Namibian quarry and allied workers are more inclined to occupational-related lung disease risks as well as negative attitudes, inadequate knowledge and bad practices in respiratory protection equipment (Shihepo et al., 2024). During training, employees interact with trained professionals who can provide instruction and understanding in the correct use of PPEs which will serve to overcome employee resistance to proper PPE usage (National Institute for Occupational Safety and Health, 2021). Educational and training programmes on safety precautions and behaviours, especially proper use of PPE, have shown to be effective methods to increase knowledge and prevent respiratory symptoms and diseases related to quarry, construction, and allied exposures (Alemu *et al.*, 2020).

Moreover, the study results showed that all the quarry and allied workers did not undergo a mandatory initial medical examination (Shihepo et al., 2024). Health surveillance in respiratory protection is an outline of repeated employee medical assessments and getting information, which includes history tracking, regular physical examinations, chest X-rays and lung function tests (Almberg, Friedman, Rose, Go, & Cohen, 2020). In addition, NIOSH (2019) states that initial examination assists in the early detection of respirable dust-related illnesses and conditions that may make the miner more susceptible to the toxic effects of respirable dust. Thus, without initial examination, Namibian quarry and allied workers are the least protected from respiratory conditions, thereby heightening the risk of becoming impaired without early detection (Chen, Cheng, Xie, & Su, 2022). Without initial examination, early detection and intervention of respiratory illness are slowed, allowing greater disease progression and deteriorating health outcomes. Also pointed out in the findings is the inability of most quarry and allied workers to undergo periodic medical examinations. Deprived of an individual medical baseline (initial medical examinations), valuable in assessing any future health changes and a comparable point (periodic examination), the protection of quarry and allied workers from respirable dust-related illnesses is minimal (Coffman *et al.*, 2021; Shihepo et al., 2024).

Furthermore, employees were evaluated medically to be sure about their ability to use a respirator, because using a respirator may create a psychological burden on employees, depending on the type of respirator, the type of job, and the workplace condition in which the respirator is used (Shihepo et al., 2024). Medical surveillance measures include medical examinations which review an employee's medical and work history and a physical examination. The medical and work history covers an employee's present and past work exposures, illnesses, and any symptoms indicating respirable dust-related diseases and compromised lung function (Lancet, 2019).

In the present article, most quarry and allied workers were not provided with PPE/C despite it being a mandatory obligation enshrined in the Namibian Labour Act. Without PPE/C protection, from respiratory conditions is jeopardised. Personal protective equipment (PPE) controls are the last line of defence in protecting workers from dust exposure when engineering and administrative controls are not feasible or do not provide adequate protection (Alemu *et al.,* 2020). The study noted that the majority of those provided with PPE/C were given free of charge. These findings are in line with the fact that respirators approved by NIOSH and suitable for their intended purpose must be provided by employers at no cost to mine and construction workers to effectively protect themselves from respirable dust (Alemu *et al.,* 2020). Workers being given respirators for free at work lessens their susceptibility to respirable dust (Shihepo et al., 2024).

The use of PPE/C among quarry and allied workers was inconsistent, as most individuals occasionally used PPE/C. These findings imply that Namibian quarry and allied workers lack adherence to the use of PPE/C; hence, they become susceptible to developing respiratory conditions and related illnesses (Shihepo et al., 2024). According to Ashley and O'Connor (2017), PPE provides direct protection to workers as a supplementary control. Compliance with respiratory protection guidelines in many industries is troublingly low, especially among workers in construction and mining (Dhatrak and Nandi, 2020). Conversely, the use of PPE decreased the intermediate risk of respiratory injury by 44%, the maximum risk by 32%, and increased the chances of no risk of respiratory effects by 24% (Yarpuz-Bozdogan, 2018).

Premised on the findings, the type of PPE/C given to Namibian quarry and allied workers is biased towards protecting the general body (overalls) rather than the respiratory system, which is the priority given the nature of their work. With very few employees using respirators, the degree of protection becomes low thereby placing an increased risk of respiratory adverse health effects associated with exposure to respirable dust. NIOSH (2019) recommend the use of respirators as an interim measure when engineering and administrative controls are not effective in maintaining worker exposure to respirable dust at or below the proposed PEL (Shihepo et al., 2024). Contrary to the findings of the current article, the use of respirators as an interim measure in maintaining worker exposure to respirable dust at or below the proposed PEL is recommended (NIOSH Health, 2019).

Evidence from the article findings revealed the use of disposable N95 and surgical masks against respirable dust exposure. Lee *et al.* (2005) contend that respirators have different levels of protection and are used in a variety of conditions; hence, it is important to understand which respirator will protect against specified dust PEL exposures. Disposable N95 respirators protect against larger dust particles, of which quarry mines and construction sites can generate smaller and finer particles (Zgambo, 2015). Conversely, half-facepiece respirators protect from smaller particles of dust, and full-facepiece respirators provide eye and respiratory protection. On the other hand, surgical masks are the least protective with a filtration efficiency between 25.7-61.5%, and half-facepiece P100 respirators were the most protective with 96.5-98.9% filtration efficiency (Sapbamrer *et al.*, 2021; Shihepo et al., 2024). Therefore, the continued dust exposure by the quarry and allied workers emphasises the importance of filtering facepiece respirators (FFRs) in dusty environments (Lee *et al.*, 2005).

The findings also showed that of the employees supplied with respirators, none did not obtain respirator fit testing. In the total absence of respirator fit testing, it is axiomatic that quarry and allied works in Namibia are not adequately protected against breathing respirable dust and contaminated ambient air (Shihepo et al., 2024). Research supports the use of respirators for lung protection while working with hazardous occupational inhalants; hence, fit testing becomes necessary to ensure maximum respiratory protection (National Center for Environmental Health, 2014). Respirator fit testing is performed to confirm the correct mask size without air leaks to protect individuals from hazardous inhalants (Ashley & O'Connor, 2017). This means that before an employee is required to use any respirator facepiece, the employee must be fit-tested with the same make, model, style and size of respirator that will be used. As revealed by the study findings, less than half of the quarry and allied workers were not adequately protected by respirators due to excessive facial hair. The use of respirators is commonly affected by fit factors such as facial hair (Shihepo et al., 2024). If a tight seal is not maintained between the facepiece and the employee's face, contaminated air will be drawn into the facepiece and breathed by the employee (Rengasamy et al., 2017). In general, the presence of beards and wide sideburns had a detrimental effect on the performance of the respirators (Jacobsen et al., 2021). This means that Namibian quarry and allied workers with excessive facial hair, including stubble and wide sideburns, which interfere with the seal, cannot expect to obtain as high a degree of respirator performance as clean-shaven individuals (Shihepo et al., 2024). OSHA concludes that poorly fitting facepieces expose workers to contaminants and that the use of an effective fit testing protocol is the best way of determining which respirator facepiece is most appropriate for each employee (Momyer, 2016).

Premised on the regression model, the level of education, age, working experience, and worksite risk perception predict or influence how quarry and allied workers are protected from respiratory infections and conditions (Shihepo et al., 2024). Research published across various occupations shows several individual factors as important determinants of the level of respiratory protection among quarry and allied workers. These factors include personal characteristics such as age, gender, work experience, level of education, knowledge (training) of respiratory protection hazards and risk perceptions of respiratory protection (Z'gambo, 2015). The educational level of quarry and allied workers greatly influenced respiratory protection. Lower educational levels of primary level and below as noted among most Namibian quarry and allied workers, entail lower respiratory protection, as some of the employees might fail to comprehend and apply respiratory protection information. A study by Almberg, Friedman, Rose, Go and Cohen (2020) found that the respondent's level of education significantly affected respiratory protection, particularly when comparing respondents with and without formal education. However, the difference between individuals with basic education and those with higher education was not statistically significant. Research findings by Jacobsen, Schaumburg, Sigsgaard and Schlünssen (2021) showed that people who did not complete formal education also did not protect themselves from respiratory hazards as they shunned the proper PPEs at work (Shihepo et al., 2024).

Worksite risk perception has shown an influence on quarry and allied workers' respiratory protection. The protection motivation theory states that risk perception and use of personal protective equipment increase when workers have a reason for concern. In most instances, employees are cognisant of protecting themselves from respiratory conditions as a result of having suffered some respiratory illness. Sehsah, El-Gilany and Ibrahim *(*2020) settle that workers who had experienced an accident or incident in the past felt less safe and were more aware of the risks than those who had not experienced an accident or incident, hence they are more prone to protect themselves. When workers are made aware of the hazards in their workplace, they are more inclined to use PPE to protect themselves from exposure to the hazards. Conversely, if workers are provided with PPE but are not told why or how to use PPE, likely, such PPE will not be utilised. Kumar ***et al.*** (2016) point out the importance of workers having knowledge of the hazards and risks posed by their work and how they can protect themselves from these hazards (Shihepo et al., 2024).

6. CONCLUSION

The study revealed that quarry and allied workers could not effectively implement engineering controls to reduce workers' exposure to respirable dust due to the lack of an occupational respiratory health framework, safety regulations and enforcement, and education and training. The study provided evidence that most allied and quarry workers did not undergo the mandatory medical examination, as a request of limited hazards control measures. This contradicts the claim made by NIOSH, which argued that construction and mining companies should provide new employees with such examinations. Despite being mandated by the Labour Act of Namibia to provide protective equipment, the study revealed that 91 percent of quarry and allied workers in the study were not given the necessary equipment, and water sprays and misting systems were limited, thus exposing the quarry and allied workers to respiratory dust. The exposure to respiratory dust by quarry and allied workers is aligned to the Hierarchical Hazard Control Model, which states that implementing hazard controls in quarry mines highly prevents respiratory infections and is regarded as effective. Without proper equipment, workers are at risk of experiencing respiratory conditions that are detrimental to their health (Shihepo et al., 2024).

The study found that the type of PPE used by workers in Namibia is biased toward protecting the general body instead of the respiratory system. In addition, the use of PPE in the study was not consistent, and only a few quarry and allied workers used a respirator, which means that their level of protection was low.

This could result in adverse health effects because of exposure to dust. The study revealed that none of the employees had obtained a fit test. It is apparent that allied and quarry workers in Namibia do not have the required protection against dust and air contamination. The study showed that less than half of the employed individuals had adequate protection due to their facial hair (Shihepo et al., 2024). The study supports the concept of the protection motivation theory, which states that when workers are concerned about their safety, they tend to use more protective equipment, but also workers with inadequate knowledge, training and education about workplace hazards control measures still risk respiratory dust exposure.

7. RECOMMENDATION

The study recommends the need for an occupational respiratory health framework specifically for quarry and allied workers to ensure control measures are adequately implemented and enforced. Quarry mines should also ensure daily health and safety checks and periodical medical testing for all quarry and allied workers to ensure that medical fit testing for PPE in dust conditions. Finally, the study also recommends education and training to enhance safety awareness for quarry and allied workers.

8. STUDY IMPLICATIONS

The practicality of the study implies that there is a need for an occupational respiratory health framework, policy enforcement, and education and training to enhance quarry and allied workers' safety. These implementations will adequately help the Namibian Labours Act to make provisions specifically for quarry and allied worker protection.

The study also contributes to the literature as it is aligned with the Protection motivation theory and the Hierarchical hazard control model, by revealing that when workers are concerned about their safety, tend to use more protective equipment.

Finally, on a policy level, the study shows an urgent need for an occupational respiratory health framework for quarry and allied workers to ensure occupational respiratory health.

Effective government policy that will enhance occupational safety and health in mining and quarrying is necessary for accident prevention in Namibia.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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