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# Knowledge, Attitudes, and Practices on Occupation Health and Safety Amongst Mine Workers Exposed to Crystalline Silica Dust in a Low-Income Country: A Case Study from Lesotho

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**Abstract:** Exposure to respirable crystalline silica dust is one of the most common and severe risks due to the associated health outcomes among workers and results in many occupational-related lung diseases, such as silicosis and lung cancer. The study aimed to determine knowledge, attitudes, and practices on occupation health and safety among mine workers exposed to crystalline silica dust in Lesotho. A descriptive retrospective cross-sectional study design was used in the study. A record review guide was used to retrieve secondary data from the Southern Africa Tuberculosis and Health Systems Support (SATBHSS) project, which were thereafter entered into STATA software, version 17 for descriptive and inferential analysis. The study participants were purposively selected. Most participants were between the ages of 31 to 40 years of age and there was a significant difference between the genders with 35 (9%) females and 350 (91%) males. The majority of the participants had a high school level of education (305, 79%). The knowledge was generally positive in the study with a knowledge score mean of 13.43 (standard deviation: 2.99). The miners agreed with most attitude statements except for A1 (25%), A2 (35%), A3 (18%), and A4 (31%). The practice of exposed mine workers in the study was influenced by working in a dolerite mine ($p = 0.003$), knowledge score ($p < 0.001$), and having an attitude about health and safety rules at the mine ($p < 0.001$; 95% CI: 0.92 to 0.79), while age was a protective factor in the study. The findings of this study highlighted positive knowledge, attitudes, and practices toward occupational health and safety among mine workers. However, more educational programs can be implemented to ensure all mine workers understand the importance of good knowledge, positive attitude, and appropriate practices towards occupational health and safety in their environment.

**Keywords:** knowledge; attitude; practices; occupational; health; safety; mines; silica dust exposure; physical stressors; chemical stressor

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## 1. Introduction

Respirable crystalline silica is one of the most particulate airborne contaminants and a common existing mineral in occupational environments. Occupational exposures are significantly prevalent in metal, construction, clay manufacturing, and most importantly, in the mining industries [1]. Globally, reports suggest that approximately 1.7 million workers are occupationally exposed to respirable silica-enriched dust in the United States, 2 million in Europe, and more than 23 million in China [2]. Mine workers are exposed to considerably hazardous concentrations of respirable crystalline silica which are likely to impact their respiratory, renal, and auto-immune systems [3], and most importantly cause silicosis. Silicosis is a chronic lung disease caused by exposure to respirable silica fraction, mainly released during mining processes such as drilling, blasting, and ore transport [3]. In Africa, mines are highly concentrated in the southern parts of the continent and are regarded as economic drivers of countries' sustainability development, particularly in the low- and middle-income regions of the Southern African Development Community (SADC). In this region of Africa, there has been growing evidence of silicosis among black miners [4,5], particularly those regarded as Lesotho migrants [6]. For centuries, Lesotho has remained an exporter of miners for South African mines and remains a home country for many ex- and current miners working in Lesotho mines and others in the entire SADC region [7]. This suggests that respirable silica-enriched dust is the most common occupational exposure risk among miners in Lesotho mines [8].

The prevalence of silicosis in miners working in Lesotho increased from 26.6% to 27% annually [8]. Prevention efforts have been taken to reduce silica exposure for many decades such as the development and implementation of some controls [9]. However, despite silica exposure controls being put in place in Lesotho mines and progress in technological developments to control, there is still an urgent need to efficiently manage silica exposure in this country [10,11]. Although it is apparent that silica exposure at high levels is potentially hazardous, little is known about the risk factors that influence exposure to silica [12]. Mitigation strategies only focusing on the technical elements are insufficient to address the issues of worker health promotion [13]. Workers are inherently ignorant to adhere to personal controls due to a lack of exposure risk knowledge and cannot adequately anticipate the exposure and health risks. It is anticipated that a lack of knowledge, awareness, and education among Lesotho's mine workers could influence the adherence to control measures for exposure to respirable crystalline silica. Therefore, it is important to understand the problem at hand; there is a need to evaluate the knowledge, attitudes, and practices of mine workers on risk factors that increase the risk of silica dust exposure in the selected mines in Lesotho.

The study aimed to evaluate the knowledge, attitudes, and practices on occupation health and safety among mine workers exposed to crystalline silica dust in Lesotho, where it looked at the use of knowledge to change workers' perceptions and to promote good practices that support all workplace exposure controls. This will help to improve mine workers' knowledge of silica exposure risk to prevent the development of silicosis. Moreover, the study enhances understanding of knowledge and practices of risk factors that influence silica exposure among mine workers in Lesotho and other countries with similar exposure scenarios/demographics. Lastly, the findings of this study will help policymakers in devising measures that will minimize the prevalence of silicosis through the use of soft science; complementing the hard science which is often central to technical occupational hygiene data.

## 2. Materials and Methods

### 2.1. Study Design and Setting

The study used a descriptive retrospective cross-sectional study design, consisting of a quantitative method. This study employed secondary data from the Southern Africa Tuberculosis and Health Systems Support (SATBHSS) project. The study was conducted in 5 Lesotho mines, within 11 active mines across the country, mining various minerals. The targeted mines were those that mined the three commodities, diamonds, sandstone, and quarries.

### 2.2. Study Population and Sampling

The study population included mine workers in Lesotho. The study purposeful targeted mine workers who are exposed to respirable crystalline silica dust during mining operations. The study identified and selected 5 mines (two large (diamonds), one medium (sandstone), and two small mines (quarries)). Furthermore, to select study participants purposive sampling approach was used to ensure that only those who were exposed to respirable crystalline silica were invited and participated in the study. According to [14] there was an estimation of 53,467 miners in Lesotho. EpInfo was used to determine the sample size using the formula below. The population size was set as 53,467, the anticipated frequency was set at 50% (because of the unknown prevalence of knowledge frequency), the precision was 5%, and the design effect of 1.0. Therefore, the study sample size was 382; see more details in Equation (1).

$$\text{Sample size } (n) = [\text{DEFF} \times \text{Np}(1 - \text{p})]/[(\text{d2}/\text{Z21} - \alpha/2 \times (\text{N} - 1) + \text{p} \times (1 - \text{p})] \quad (1)$$

where N is the population, p is the prevalence of poor knowledge, d = precision, DEFF is the design effect, and $Z1-\alpha/2$ is set at 1.96.

### 2.3. Record Review Guide

The primary data were collected using a self-administered structured questionnaire to collect data for the initial study by SATBHSS. The questionnaire in the initial study was designed using existing literature and using expert advice. Furthermore, the study question's validity and reliability were checked by piloting before the actual study. For the current study, secondary data were used, where records from 2019 to 2021 and a record review guide were used to collect data on participants' socio-demographics, knowledge, attitudes, and practices related to occupational health and safety among crystalline silica dust-exposed mines. The secondary data were retrieved, cleaned, and coded by V.L. The data were then verified by N.K., P.C.R., T.P.M. and M.D.M.

#### 2.3.1. Socio-Demographics, Knowledge, and Attitude Factors

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

We collected data on the study participants' attitudes towards exposure, health issues, occupational health and safety, and controls related to their work environment. The attitude questions had two responses, it was either disagree (coded as 0) or agree (coded as 1). The participants were asked if they disagreed or agreed with the following statements in the initial study:

- Attitude 1 (A1) I think our work is meant for the brave and not for people who are worried about Health & Safety,
- Attitude 2 (A2), I consider minor accidents as a normal part of my daily work,
- Attitude 3 (A3), health and safety laws are biased against the small -scale miners,
- Attitude 4 (A4), it is difficult to follow health and safety procedures,
- Attitude 5 (A5), workers react strongly against other workers who break health and safety rules,
- Attitude 6 (A6), I feel safe in my work environment.
- Attitude 7 (A7), mine dust is the cause of diseases such as pneumoconiosis, silicosis, lung cancer and mesothelioma.
- Attitude 8 (A8), high levels of dust exposure in mines could be a cause of occupational lung diseases amongst mineworkers. and

- Attitude 9 (A9), Do you think some ex-mineworkers got ill or died due to exposure to crystalline silica or mine dust?

**Table 1.** Questions on the study participants' knowledge.

| Question | | Variable |
|---|---|---|
| 1. | Are you aware that there is a need for occupational health and safety (H & S) policy in the workplace? | H&S policy knowledge |
| 2. | Do you know and understand company Health and safety policies? | Company H&S policies |
| 3. | Are you trained on Occupational Health Safety hazards? | Training on OHS |
| 4. | Are you trained on occupational health and safety policy and related requirements? | OHS policies |
| 5. | Does exposure to respirable crystalline silica cause lung cancer? | Lung cancer |
| 6. | Do you know the risk associated with high temperature? | High temperature |
| 7. | Do you know the risks associated with carbon monoxide poisoning? | Carbon monoxide poisoning |
| 8. | Do you know the risks associated with nervous system problems? | Nervous system problems |
| 9. | Do you know the risk associated with hand-arm vibration? | Hand-arm vibration |
| 10. | Do you know the risks associated with the causes of silicosis? | Causes of silicosis |
| 11. | Do you know the risk associated with high noise exposure? | Levels of noise |
| 12. | Do you know the risks associated with chemical stressors? | Chemical stressors |
| 13. | Do you know the risk associated with biological agents? | Biological stressors |
| 14. | Do you know the risk associated with physical stressors? | Physical stressors |
| 15. | Do you know the risk associated with safety stressors? | Safety stressors |

### 2.3.2. Outcome Variables

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

**Table 2.** Questions on the practices related to occupational health and safety among miners exposed to crystalline silica dust.

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

*2.4. Data Analysis*

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

*2.5. Ethical Considerations*

The study was ethically cleared by the Witwatersrand University Human Research Ethics (M231180). Permission to use the main research study results was granted by AUDA-NEPAD. For security reasons, the data obtained from the main study were protected and only accessible to the investigators to ensure confidentiality.

## 3. Results

*3.1. Characteristics of Study Participants*

The age distribution shows that 122 participants were between the ages of 21 to 30 years old, 167 were between the ages of 31 to 40 years, 57 were between 41 to 50 years, 34 were between 51 and 60 years old, and 5 were 61 years and above, making up a total of 385 participants. Most of the participants were between the ages of 31 to 40 years of age. The results presented in Table 3 illustrate the level of education achieved by the participants and other participant characteristics. Individuals with a postgraduate degree accounted for 10 (3%) of the total participants, compared to 25 (6%) of those with a degree as their highest level of education. Those who had a diploma as their highest level of education were 45 (12%), and the rest of the participants had a secondary education level of education, which was 305 (79%). A total of 350 (91%) males and 35 (9%) females working in Lesotho mines participated in the dust monitoring survey. Approximately 275 (71%) participants were single, while 105 (27%) participants were married, and 5 (2%) participants were widowed. About 175 (45%) participants were working as general workers, one thirty-five (35%) working as plant operators, 30 (8%) working as supervisors, 30 (8%) working as technicians, and 15 (4%) working as drivers. The primary commodities mined in Lesotho are mainly diamond, sandstone, and dolerite with 185 (48%), 120 (31%), and 80 (21%), respectively.

*3.2. Knowledge of Respiratory Crystalline Silica Dust among Mineworkers*

The results in Figure 1 show participants' correct and incorrect knowledge responses regarding occupational health and safety as well as potential hazards and health outcomes in their working environment. This study revealed good knowledge of lung cancer, level of noise, and safety stressors with 91%, 99%, and 96%, respectively. At the same time, there is a significant difference in the knowledge of physical stressors; the study showed that 90% of the participants did not know about physical stressors in their workplaces. Furthermore, the average knowledge was 13.43 with a standard deviation of 2.99, while the knowledge score ranged from 6 to 19 and the median was 14.00.

**Table 3.** Characteristics of the study participants.

| Characteristics | Number (*n*) | Percentage (%) |
|---|---|---|
| | Age | |
| 21 to 30 years old | 122 | 32% |
| 31 to 40 years old | 167 | 43% |
| 41 to 50 years old | 57 | 15% |
| 51 to 60 years old | 34 | 9% |
| 61 years old and above | 5 | 1% |
| | Gender | |
| Male | 350 | 91% |
| Female | 35 | 9% |
| | Marital Status | |
| Single | 275 | 71% |
| Married | 105 | 27% |
| Widowed | 5 | 2% |
| | Education | |
| Secondary Education | 305 | 79% |
| Diploma | 45 | 12% |
| Degree | 25 | 6% |
| Postgraduate Degree | 10 | 3% |
| | Job Title | |
| Drivers | 15 | 4% |
| General Workers | 175 | 45% |
| Plant Operators | 135 | 35% |
| Supervisors | 30 | 8% |
| Technicians | 30 | 8% |
| | Years Working in the Mine | |
| 1 to 10 years old | 285 | 74% |
| 11 to 20 years old | 90 | 23% |
| 21 years and above | 10 | 3% |
| | Primary Commodities | |
| Diamonds | 185 | 48% |
| Sandstone | 120 | 31% |
| Dolerite | 80 | 21% |

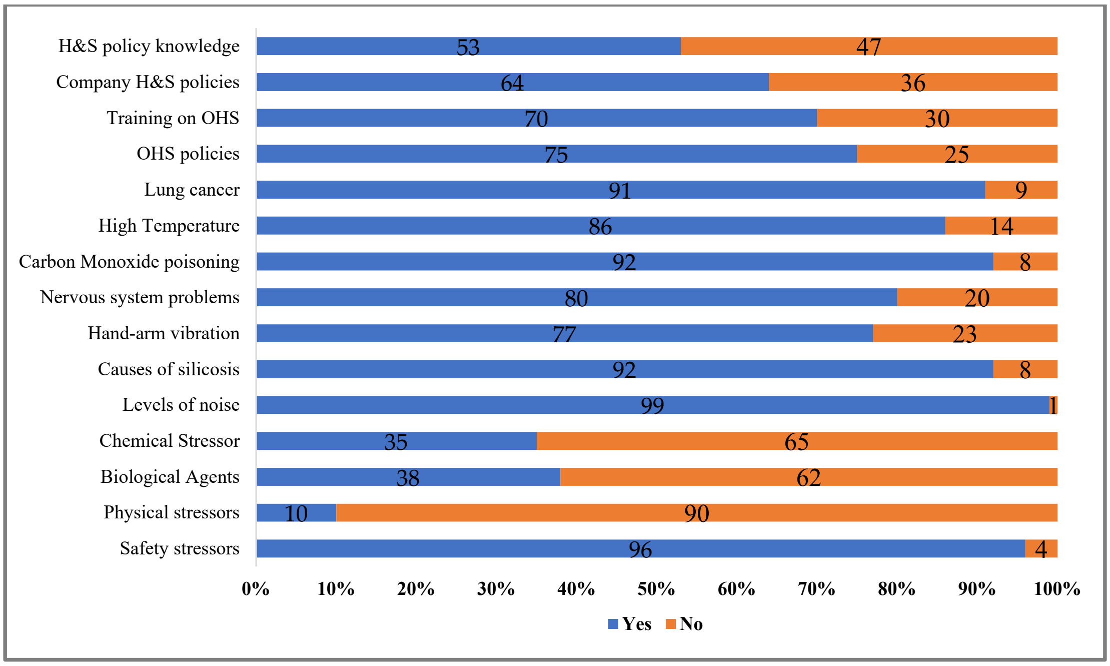


**Figure 1.** Participants' knowledge response on respiratory crystalline silica dust.

### 3.3. Study Participants' Attitude

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

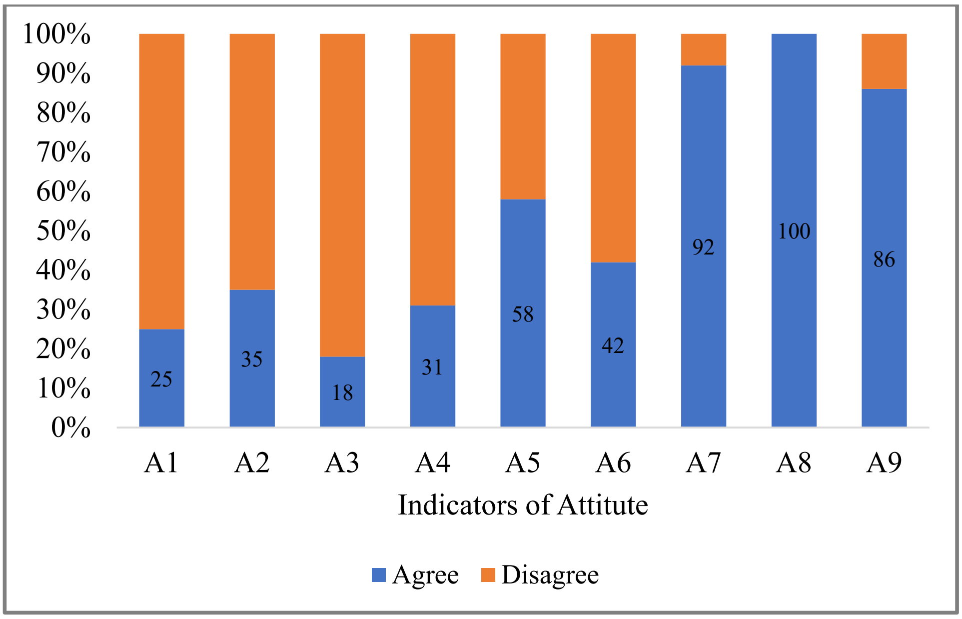


**Figure 2.** Workers' attitudes on factors or conditions leading to dust exposure.

### 3.4. Practices Linked to Prevention and Protection against Respiratory Crystalline Silica Dust

According to Table 4, 210 (55%) of participants who work in Lesotho mines reported having evidence of health and safety implementation strategy in their workplace. A total of 230 (60%) reported holding health and safety meetings regularly, 155 (40%) participants reported that their employer conducts dust and noise surveys at regular intervals, while 250 (65%) participants reported that the employer conducts individual risk assessments prior to commencing their duties.

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

**Table 4.** Participants' practice in the study.

| Practice | Total |
|---|---|
| 1. There is evidence of health and safety implementation strategy in my company. | 210 (55%) |
| 2. Do you hold health and safety meetings regularly? | 230 (60%) |
| 3. Does your employer conduct dust and noise surveys at regular intervals? | 155 (40%) |
| 4. The employer conducts individual risk assessments prior to commencing your duties as an employee. | 250 (65%) |
| 5. There is a health and safety representative in my work area. | 215 (56%) |
| 6. Taking air measurements for dust at the mine is good practice for controlling dust exposures? | 175 (46%) |
| 7. Spraying water/chemical agents on travel/haul roads is an effective way to reduce dust levels. | 375 (97%) |
| 8. Keeping the dump truck's cabin door closed is a good practice to keep dust levels low inside. | 340 (88%) |
| 9. Wearing a dust/paper mask is important when working in dusty areas. | 365 (95%) |
| 10. Wearing a dust/paper mask is important when working with chemicals, gases or vapours. | 345 (90%) |
| 11. I can protect my hands from workplace hazards/risks by wearing good protective gloves. | 350 (91%) |
| 12. Following approved re-entry times after blasting will limit your exposure to dust and blasting fumes/gases. | 265 (69%) |
| 13. Wearing hearing protection (earplugs/earmuffs) at work will protect you from going deaf. | 300 (78%) |
| 14. I have received health and safety awareness training within the last 12–24 months. | 180 (47%) |

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

### *3.5. Factors That Influence the Practice Related to Respiratory Silica Dust Prevention in the Study*

The bivariate analysis between practice score and socio-demographic variables is presented in Table 5. The analysis showed that there was an association between practice scores with age ($p \leq 0.001$), education ($p \leq 0.001$), job title ($p \leq 0.001$), gender ($p = 0.005$), occupation ($p \leq 0.001$), and commodity mined ($p \leq 0.001$). The bivariate analysis showing the knowledge and attitude variables influencing the practice are presented as A1 and A2, respectively. This finding suggests that with improved knowledge a positive attitude and practice can be achieved.

**Table 5.** Bivariate regression analysis of socio-demographics influencing the practice score.

| Socio-Demographics | Coefficient | *p*-Value | 95% Confidence Interval |
|---|---|---|---|
| Age | 0.91 | ≤0.001 * | 0.61 to 1.22 |
| Education | 0.75 | ≤0.001 * | 0.32 to 1.18 |
| Gender | 1.53 | 0.005 * | 0.46 to 2.59 |
| Job Title | 0.59 | ≤0.001 * | 0.27 to 0.91 |
| Years Working in the Mine | 0.50 | 0.123 | 0.14 to 1.13 |
| Primary Commodity | −2.33 | ≤0.001 * | −2.65 to −2.01 |

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

The final multivariate linear regression showing factors influencing the practice in the study is presented in Table 6. The following factors influence practices related to occupational health and safety in the study: working in a dolerite mine ($p = 0.003$; 95% CI: 0.35 to 1.66), knowledge score ($p < 0.001$; 95% CI: 0.37 to 0.59), having positive (agree) attitude towards minor accidents at the mine ($p = 0.007$; 95% CI: −1.05 to −0.16), and having positive (agree) attitude about health and safety rules at the mine ($p < 0.001$; 95% CI: 0.92 to 0.79). Being 31 to 40 years old ($p <0.001$; 95% CI: 0.35 273 to 1.03) was a protective factor in the study.

**Table 6.** Multivariate linear regression shows factors influencing the practice in the study.

| Factor | Coefficient (Std. Error) | p-Value | Confidence Interval [95% CI] |
|---|---|---|---|
| | | Age | |
| 21 to 30 years old | | ref | |
| 31 to 40 years old | 0.68 (0.17) | <0.001 * | 0.35 to 1.03 |
| 41 to 50 years old | −0.54 (0.23) | 0.020 * | −0.99 to −0.08 |
| 51 to 60 years old | −0.91 (0.31) | 0.003 * | −1.52 to −0.30 |
| 61 years old and above | −1.65 (0.60) | 0.007 * | −2.83 to −0.46 |
| | | **Primary commodities** | |
| Diamonds | | ref | |
| Sandstone | −0.31 (0.26) | 0.241 | −0.83 to 0.20 |
| Dolerite | 1.01 (0.33) | 0.003 * | 0.35 to 1.66 |
| | | ***Knowledge Score*** | |
| Score | 1.48 (0.06) | <0.001 * | 0.37 to 0.59 |
| | | **Attitude toward minor accidents at the mine** | |
| Disagree | | ref | |
| Agree | 1.61 (0.23) | 0.007 * | −1.05 to 0.16 |
| | | **Attitude about health and safety rules at the mine** | |
| Disagree | | Ref | |
| Agree | 1.36 (0.22) | <0.001 * | 0.92 to 1.79 |

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

## 4. Discussion

### *4.1. Demographics*

The demographic of participants is represented in the results section above. A total of 385 participants aged from 21 to 61 years and above participated in this cross-sectional study designed to gain insight into the knowledge, attitudes, and practices of mine workers on factors that increase the risk of silica dust exposure in selected mines in Lesotho. Most of the participants were between the age of 31 to 40 years of age and there was a significant difference between the genders with 35 (9%) females and 350 (91%) males. The majority of the participants had a secondary education level of education which was 305 (79%). A total of 275 (71%) participants were single, while 105 (27%) participants were married, and 5 (2%) participants were widowed. A total of 185 (48%) participants reported working as general workers, 155 (40%) working as plant operators, 30 (8%) working as supervisors, and 15 (4%) working as drivers. The primary commodities mined in Lesotho are mainly diamond, sandstone, and dolerite with 185 (48%), 120 (31%), and 80 (21%), respectively.

The knowledge regarding silica dust exposure risk factors among mine workers was determined. The findings of this study revealed good knowledge of lung cancer, level of noise, and safety stressors with 91%, 99%, and 96%, respectively. In addition, most of the workers (75%) knew about the preventative safety precautions through OHS policies. However, this study further revealed a significant difference in knowledge of occupational hazards such as physical stressors, chemical stressors, and biological stressors. The findings indicated that 90% of the mine workers were unaware of the physical stressors present in their work environments, with 65% and 62% lacking knowledge of chemical and biological hazards, respectively. A previous study highlighted that chemical, physical, ergonomic, biological, and psychosocial stressors in workplaces interact to create a comprehensive system that imposes a collective stress burden on mine workers, ultimately resulting in work-related diseases [15]. This research study findings further demonstrated an average knowledge of 13.43 with a standard deviation of 2.99, while the knowledge score ranged from 6 to 19 and the median was 14. Therefore, the findings of this study imply that there was a decline in knowledge of risk factors influencing workers' exposure to silica dust.

The findings of this study concur well with a study conducted by the authors of [12] which reported that little is known about the risk factors that influence workers' exposure to silica dust in mining industries. Another study by the authors of [16] also supports the findings of these two studies that, there is still a lack of knowledge regarding silica dust exposure, particularly in the SADC region. However, contrary findings were reported in a study conducted by the authors of [7], which found that there has been an increase in knowledge on silicosis in miners from the early twentieth century. Therefore, to understand the problem at hand, there is a need for further evaluation of the knowledge of mine workers on factors that increase the risk of silica dust exposure in selected mines in Lesotho.

In terms of attitudes on silica dust exposure risk factors among mine workers in Lesotho, this study revealed that most respondents had a positive attitude toward safety practices and the prevention of occupational hazards. This was shown by 100% of the respondents who believed that high dust exposure in mining operations could be the reason mine workers develop occupational lung diseases. The findings of this research align with those of a previous study carried out by the authors of [17], where workers exhibited a strong appreciation of attitudes towards occupational exposure.

About 70% of the respondents reported that they attended training on occupational health and safety precautions. However, more than half, 65% of the respondents, believed that minor accidents are normal parts of the work's daily activities. The findings of this study imply that a comprehensive understanding and knowledge of the factors influencing the risk of silica dust exposure is crucial for cultivating positive attitudes in mining operations. This finding concurs well with a study conducted by the authors of [16], which demonstrated the significance of knowledge in fostering positive attitudes that can promote proper workplace practices to minimize respirable dust exposure.

Understanding and implementing effective practices for the prevention and protection against respirable crystalline silica is paramount in mining operations. Table 4 presents summaries of mine workers' responses to questions related to practices linked to prevention and protection against silica dust. It emerged from the findings of the current study that, the majority (95%) of the participants reported that wearing a dust/paper mask was important when working in dusty areas. Notably, 91% of participants reported that they protect their hands from workplace hazards/risks by wearing good protective gloves. The analysis further shows that 78% of the participants wear hearing protection devices (earplugs/earmuffs) at work as a protection from becoming deaf. However, predominantly depending on hearing protection devices is not considered a sound practice [18]. A previous study by the authors of [19] reported that attitudes and practices are significantly influenced by the education workers receive on noise-induced hearing loss (NIHL) and the existing occupational health and safety culture within the industry.

The study further showed that the overall practices of the majority of the mine workers were reasonably good. This is corroborated by the findings of a study conducted by the authors of [20], where it was observed that mine workers exhibited a profound understanding and knowledge of health-protective practices in relation to respirable silica dust exposure to the point that they demonstrated a commitment to wearing respiratory protective equipment, even in locations where its usage was not required. However, there was a significant difference relating to mine worker's practices.

It was observed that a low percentage, 40% of the study population, reported that their employer conducts dust and noise surveys at regular intervals. Additionally, the study revealed that only 46% of the participants reported taking air measurements for dust at the mine as a good practice for controlling dust exposure. Furthermore, it was found that 53% of the participants indicated that they never received health and safety awareness training within the last 12–24 months. The study findings indicate that the management of the mining sites must implement education programs aimed at improving knowledge and understanding of the risks associated with exposure to respirable silica dust. Therefore, this study highlighted a need to integrate administrative controls such as knowledge and behavioral components into the established controls, to further reduce the excessive exposure of mine workers to respirable crystalline silica dust.

The current study demonstrated a notable impact of knowledge and attitude on practices regarding risk factors that influence exposure to silica. This finding implies that enhanced knowledge and a positive attitude can lead to improved practices.

The final multivariate linear regression showing factors influencing the practice in the study is presented in Table 6. The relationship between mine worker's age and the level of understanding of respirable silica dust exposure revealed some intriguing results. It is generally expected that elderly workers demonstrate a better and greater understanding of occupational health and safety issues. Surprisingly, this study's results showed a different picture. The results of this study indicated a significant correlation between middle-aged, 31 to 40 years old ($p < 0.001$; 95% CI: 0.35 to 1.03) mine workers and the level of knowledge of the factors contributing to the risk of silica dust exposure, whereas older workers, 61 years old and above were more likely to be ignorant of those factors. This finding contradicts the findings of the authors of [21] who found that older employees were more aware of workplace health hazards than their younger counterparts. Another study conducted by the authors of [22] also yielded contradictory findings. The results of this study do not agree with the body of existing literature in this regard, and this could potentially be attributed to the demographic makeup of the current study participants, who predominantly consisted of middle-aged mine workers. This composition may have inadvertently introduced a response bias.

The number of years worked in mining operations was determined. This study's findings showed that work experience has a significant effect on the level of awareness of the factors influencing the risk of silica dust exposure among mine workers in Lesotho. Individuals who spent 11 years or more working in mine industries demonstrated a superior understanding and knowledge of the factors contributing to the risk of silica dust exposure than those who have been in the industry for less than 11 years. This finding concurs with what the authors of [23] found in their studies that the more the experience of years worked in mining operations, the more the knowledge of adverse health effects of silica dust exposures. A study by the authors of [24] also discovered a positive correlation between increased work experience and workers' awareness of occupational health hazards.

The study results suggest that mine workers with higher levels of education are more aware of the health risks associated with silica dust exposure than those with only primary or no education. This implies that a worker's understanding of the implications of silica dust exposure improves with education. This finding is not surprising because higher-educated workers are usually better informed on issues regarding occupational health hazards. The study by the authors of [25] on knowledge, attitudes, and perceptions of occupational hazards and safety practices in healthcare workers found that educational status is positively associated with occupational health knowledge. In addition to this, a study by the authors of [21] revealed that highly educated people are more likely to understand hazardous exposures and take precautions to prevent them. Based on our findings, we can conclude that higher educated mine workers can read and understand the health hazards associated with silica dust exposure than those with lower education or no education. It has been established that higher educational attainment is significantly associated with worker's health hazard awareness [24].

The concept of occupational health services access is a fairly new discipline that is in its infancy, and Lesotho is no exception [26]. In the late 1990s, the TB incidence rate among gold mineworkers in Southern Africa ranged between 3000 and 7000 cases per 100,000 workers; notably Lesotho contributes around 25% of Southern African mine workers [27]. This highlights the severe impact of mining-related health issues during that period. Data from 2006 to 2016 show that in 2016, the gold sector was responsible for a significant proportion of PTB cases in South Africa's mining industry gold sector: 55.7% of total PTB cases; platinum sector: 30.2% of total PTB cases; and coal sector: 7.1% of total PTB cases. These data underscore the continued high incidence of PTB among mineworkers, particularly in the gold and platinum sectors. The high rates of PTB in these sectors can be attributed to several factors, including the inhalation of silica dust and the confined, often dusty, working conditions in mines [28]. Given the lack of recent and reliable statistics for Lesotho and the broader Southern Africa region, it is vital to advocate for improved monitoring and reporting of occupational diseases and injuries [29].

Since the establishment of the SATBHSS, Lesotho has made significant strides in improving occupational health and safety practices in the mining sector. The completion of the occupational safety and health profile led to the development of a national policy on OSH to advance proper OHS practices. The national OHS policies embraced activities such as joint inspections of mines, training of occupational medical doctors on ILO classification, occupational hygienists on Occupational Hygiene Training Association (OHTA) modules, and training of inspectors [30]. The country has also adopted the regional inspection tool created under the SATBHSS project to ensure quality control in the provision and evaluation of safe workspaces. However, the level of maturity of the OSH practice remains suboptimal due to a lack of capacity in the ministries especially in human resources and infrastructure development [28,31]. The Mines and Minerals Act of 2005 (Part IV) of Lesotho obliges owners of prospective licenses to take reasonable steps to ensure the safety, welfare, and health of employees while the Labour Code Order (Part VII) obliges the employer to take full responsibility for a safe working environment.

### *4.2. Limitations of the Study*

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

### *4.3. Strengths of the Study*

This is relatively the first study to fill the research gap on worker exposure to crystalline silica among mine workers in Lesotho, according to our knowledge. The study also assessed how knowledge could influence the attitude and worker practices towards exposure to crystalline silica, and this contributes significantly to informed decision-making on exposure control. The findings of this study may serve as the basis for international policy adoption and implementation.

## 5. Conclusions

The findings of this study have highlighted that, although mine workers have indicated to have health and safety programs in their areas of work in place, to foster good practices for prevention and protection against exposure to crystalline silica dust, there were shortcomings in the implementation of some elements of the program, in particular with regard to health and safety information and occupational crystalline silica dust exposure monitoring. This study's findings also highlighted inadequate control of workplace crystalline dust exposure. Therefore, the workers in these mines are potentially at risk of contracting silicosis, silico-tuberculosis, lung cancer, and other occupational respiratory diseases associated with exposure to crystalline silica dust, including the risk of contracting tuberculosis. Furthermore, there is still an urgent need to efficiently manage silica exposure through the use of knowledge to change workers' perceptions and to promote good practices that support all workplace exposure controls. The findings of this study provide crucial information for policymakers to devise measures that will minimize the prevalence of silicosis in Lesotho mines.

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**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the University of the Witwatersrand (protocol code M231180 and date of approval: 28/11/2023).

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**Data Availability Statement:** Data are available upon reasonable response from the corresponding author.

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## Appendix A

**Table A1.** Bivariate regression analysis of knowledge influencing the practice score.

| Knowledge | Coefficient | *p*-Value | 95% Confidence Interval |
|---|---|---|---|
| H&S policy knowledge | −4.30 (−7.00 to −1.60) | 0.002 * | −4.30 (−7.00 to −1.60) |
| Company H&S policies | 0.81 (−0.33 to 1.97) | 0.164 | 0.81 (−0.33 to 1.97) |
| Training on OHS | 0.62 (−0.11 to 1.34) | 0.095 | 0.62 (−0.11 to 1.34) |
| OHS policies | 1.68 (0.91 to 2.44) | ≤0.001 * | 1.68 (0.91 to 2.44) |
| Lung cancer | 2.62 (1.50 to 3.74) | ≤0.001 * | 2.62 (1.50 to 3.74) |
| High temperature | 0.34 (−0.53 to 1.23) | 0.439 | 0.34 (−0.53 to 1.23) |
| Carbon monoxide poisoning | 0.35 (−0.72 to 1.43) | 0.514 | 0.35 (−0.72 to 1.43) |
| Nervous system problems | 3.17 (2.52 to 3.81) | ≤0.001 * | 3.17 (2.52 to 3.81) |
| Hand-arm vibration | 3.18 (2.58 to 3.78) | ≤0.001 * | 3.18 (2.58 to 3.78) |
| Causes of silicosis | 4.16 (3.66 to 4.65) | ≤0.001 * | 4.16 (3.66 to 4.65) |
| Levels of noise | 4.91 (4.53 to 5.29) | ≤0.001 * | 4.91 (4.53 to 5.29) |
| Safety stressors | −2.34 (−2.91 to −0.75) | 0.004 * | −2.34 (−2.91 to −0.75) |
| Physical stressors | −1.68 (−2.67 to −0.68) | 0.001 * | −1.68 (−2.67 to −0.68) |
| Biological stressors | 0.89 (0.26 to 1.52) | 0.006 * | 0.89 (0.26 to 1.52) |
| Chemical stressors | −0.08 (−0.72 to 0.57) | 0.817 | −0.08 (−0.72 to 0.57) |
| **Knowledge score** | 0.76 (0.68 to 0.82) | ≤0.001 * | 0.76 (0.68 to 0.82) |

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

**Table A2.** Bivariate regression analysis of attitudes influencing the practice score.

| Knowledge | Coefficient | *p*-Value | 95% Confidence Interval |
|---|---|---|---|
| A1 | 1.45 (0.74 to 2.16) | ≤0.001 * | 1.45 (0.74 to 2.16) |
| A2 | −1.16 (−1.80 to −0.52) | ≤0.001 * | −1.16 (−1.80 to −0.52) |
| A3 | −0.48 (−1.284862 to 0.32) | 0.235 | −0.48 (−1.284862 to 0.32) |
| A4 | −0.85 (−1.51 to −0.19) | 0.012 * | −0.85 (−1.51 to −0.19) |
| A5 | 3.21 (2.67 to 3.75) | ≤0.001 * | 3.21 (2.67 to 3.75) |
| A6 | 3.58 (3.06 to 4.09) | ≤0.001 * | 3.58 (3.06 to 4.09) |
| A7 | 3.71 (2.62 to 4.8) | ≤0.001 * | 3.71 (2.62 to 4.8) |
| A8 | 0 (omitted) | - | 0 (omitted) |
| A9 | 2.05 (1.19 to 2.91) | ≤0.001 * | 2.05 (1.19 to 2.91) |

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

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