



Original Article

Knowledge, Attitude and Practices of Preventive Measures of Silicosis Among Small-Scale Miners at Mirerani in Manyara Region, Tanzania

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ABSTRACT

Background: Silicosis is a preventable but progressive lung disease caused by the inhalation of Respirable Crystalline Silica (RCS), posing a serious occupational risk to miners. This study aimed to assess the knowledge, attitudes, and practices related to silicosis among small-scale miners at Mirerani in Manyara Region.

Materials and Methods: A descriptive cross-sectional design was used, surveying 203 small scale miners through structured, closed-ended questionnaires. In this study, collected data were entered into the Statistical Package for the Social Sciences (SPSS) version 26 for descriptive analysis to determine the frequencies and percentages of demographic data, knowledge, attitudes and preventive practices, while results were presented in tables and figures.

Results: The majority of respondents (99%) were male. Over half (59.1%) had never heard of silicosis, and only (38.9%) recognized silica dust inhalation as its cause. A smaller proportion identified persistent cough (33.0%) as a symptom and only 29.1% used PPE such as masks as a preventive measure. More than half (54.2%) revealed negative attitudes toward silicosis prevention. In practice, 67.5% used masks as PPE and 66.5% regularly replaced them. However, 78.8% had not received any preventive training, and only 32.5% underwent routine medical evaluations. Additionally, the majority (87.7%) used water sprays for dust suppression, and 85.7% engaged in addressing health and safety issues.

Conclusion: Small-scale miners at Mirerani demonstrated low knowledge, while negative attitudes toward preventive measures of silicosis were also common. Although some miners reported using masks and water spraying to control dust exposure, few had received training on silicosis prevention or attended regular medical examinations. These findings highlight a critical need for targeted educational interventions to improve awareness and promote safe practices among small-scale miners.

Keywords: Knowledge, Attitude, Practices, Silicosis, Tanzania

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INTRODUCTION

Silicosis remains a major occupational health problem among miners worldwide, particularly in low- and middle-income countries where occupational safety measures are often inadequate [1]. Silicosis is caused by inhaling Respirable Crystalline Silica (RCS) dust, which over time leads to progressive, irreversible, and fatal inflammation and lung fibrosis [2]. The disease is characterized by progressive inflammation and irreversible pulmonary fibrosis, leading to symptoms such as chest tightness, dyspnea, cough, chest pain, hemoptysis, sputum expectoration, and subsequent complications such as respiratory tract infection, pneumothorax, and tuberculosis [3].

There are three clinical forms of silicosis, chronic (classic), accelerated, and acute. Chronic silicosis is the most common and occurs after 15–20 years of exposure to free crystalline silica dioxide particles. Accelerated silicosis can occur after 5–10 years of exposure to increased concentrations of silica dust, and the acute form usually occurs after very high exposure to silica in a period of a few months to 2 years [4]. In addition, the concentration of crystalline silica in inhaled particles must reach a certain threshold (usually >10%), and the exposure time must be at least 5 years [5]. Clinical signs may be identical to simple silicosis or maybe more serious, with the development of central cavitation increasing the risk of mycobacterial infection, enlargement of the lymph node located in the area where the major blood vessels and airways enter the lungs, pleural thickening, higher risk of complication in breathing due to difficulty in expansion of lungs caused by building up of air in the pleural space and put pressure on the lungs and weight loss [6]. Because of the lack of early diagnostic tests, treatment of silicosis is largely limited to evaluating and managing symptoms and flushing of lungs with a large amount of saline solution to wash out accumulated material is often used to improve chest tightness, chest pain, dyspnea, and other symptoms in patients with early silicosis [2].

More than 23,000 incident cases of silicosis were reported worldwide in 2017, showing significant variations between continents [7]. Globally, the prevalence of silicosis has decreased annually by 4.6% between 1990 and 2019, this decline being more pronounced in high-income countries (24.9%) than in low-middle and low-income countries (3.5% and 5.7% respectively) [3]. Therefore, the above findings show that the prevalence of silicosis in low-middle and low-income countries is still high. According to Global Burden of Disease (GBD) in Africa, silicosis accounts for 32% of all groups of interstitial lung disease caused by breathing in certain kinds of dust particles that damage the lungs cases, with new cases increasing by 24% between 1990 and 2017, Approximately 5% of deaths from pneumoconiosis worldwide occur in Africa, 20% of which are due to silicosis and the five countries with the highest number of new cases are Egypt, South Africa, Ethiopia, the Democratic Republic of the Congo, and Algeria [7]. Silicosis is rare in Tanzania, but the prevalence among miners is around 1.6% however, most current reports of silicosis burden are based on studies of large mining populations [8]. Studies in small-scale miners have shown that short-term, high-dose exposure to silica dust can lead to silicosis in as high as 29.1%. A recent review found that the prevalence of silicosis in small-scale miners ranged from 11% to 37% [9].

Previous studies have demonstrated varying levels of knowledge, attitudes, and preventive practices regarding silicosis among miners globally. In India and China, miners with regular occupational health training were more likely to recognize silica dust exposure as a major occupational hazard and demonstrated better adherence to preventive measures such as PPE use and dust suppression techniques [10]. In Africa, studies conducted in Zambia, Zimbabwe, and Lesotho reported that although some miners were aware of dust-related respiratory diseases, substantial gaps remained in recognizing silicosis symptoms, causes, and long-term complications [11-13]. In Tanzania, evidence regarding miners' knowledge, attitudes, and practices toward silicosis remains limited, particularly among small-scale miners. Existing studies have mainly focused on prevalence and lung function impairment rather than behavioral and preventive aspects [8,9]. Therefore, assessing miners' knowledge, attitudes, and preventive practices is essential for guiding occupational health interventions and policy formulation.

The Mirerani mine in northern Tanzania is the only mine in the world that mines valuable tanzanite on an industrial scale, but health and safety standards at the mine fall far short of industry standards. Also, workers are constantly exposed to harmful conditions, including dust [14]. Previous evidence suggests that high levels of mining dust, including respirable crystalline silica (1.23 mg/m³), during

mining at the Mirerani tanzanite mines are associated with the development of silicosis, in the tanzanite mines of Mirerani has been documented and simple operations such as pneumatic drills, blowers, and explosives are used, with little or no dust protection such as wet drilling or the use of PPE [8].

Despite previous studies, little is known about silicosis, and the majority of studies have been conducted based on large-scale miners compared to small-scale miners. Therefore, the aim of this research is to assess knowledge, attitudes, and practices on silicosis among small-scale miners at Mirerani in Manyara Region to provide valuable evidence for designing targeted educational programs and interventions aimed at reducing silica dust exposure and promoting occupational safety. Furthermore, the study will guide policymakers and stakeholders in formulating tailored health policies and regulations, finally enhancing the well-being and contributing to broader initiatives to safeguard the health of small-scale miners.

MATERIALS AND METHODS

Area of Study

The study was conducted at the Mirerani Tanzanite mines, located in Manyara region and specifically, the mines were situated in the Simanjiro District, with coordinates of 3° 33' 42" S latitude and 36° 58' 44" E longitude. This area is well-known for its mining activities, particularly for tanzanite, and approximately 12,000 small-scale miners in Tanzania were employed at the Mirerani mines.

Research Design

This study adopted a descriptive cross-sectional design and was conducted between March and May 2025.

Research Approach

A quantitative approach was used. Quantitative data was gathered through a structured, closed-ended questionnaire. This provided a comprehensive understanding of the small-scale miners' KAP regarding silicosis.

Population

The study population included approximately 1,000 registered small-scale miners working in Mirerani Tanzanite mines who had worked for up to five years. This population was selected because miners within this duration of employment are highly exposed to silica dust and are at risk of developing silicosis.

Inclusion Criteria

All small-scale miners who were registered in specific job roles such as drilling, blasting, and shoveling breaking activities (roles directly involved in dust).

Exclusion Criteria

Small-scale miners registered in administrative or office-based roles and those who had worked for more than five years were excluded from the study because they were less likely to have direct occupational exposure to silica dust.

Sampling Frame

The sampling frame consisted of an official list of registered small-scale miners obtained from the Mirerani mining authorities. The list included miners' identification numbers, working blocks, job categories, and duration of employment. Only miners who had worked within five years were directly involved in mining activities such as drilling, blasting, and shoveling were included in the frame.

Sample Size

The sample size was calculated using Fisher's formula for cross-sectional studies [15]:

$$n = \frac{Z^2 \times P(1 - P)}{e^2}$$

Where:

- n = required sample size
- Z = standard normal deviation at 95% confidence level (1.96)
- P = estimated proportion of small-scale miners with silicosis (20.9% or 0.209) [8]
- e = margin of error (0.05)

Substituting the values into the formula:

$$n = \frac{(1.96)^2 \times 0.209(1 - 0.209)}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.209(0.791)}{0.0025}$$

$$n = \frac{3.8416 \times 0.165319}{0.0025}$$

$$n = \frac{0.6349}{0.0025}$$

$$n = 253.96$$

Since the study population was less than 10,000 miners ($N = 1,000$), finite population correction was applied using the formula:

$$n_f = \frac{n}{1 + \left(\frac{n}{N}\right)}$$

Substituting the values:

$$n_f = \frac{253.96}{1 + \left(\frac{253.96}{1000}\right)}$$

$$n_f = \frac{253.96}{1 + 0.25396}$$

$$n_f = \frac{253.96}{1.25396}$$

$$n_f = 202.5$$

Therefore, the final sample size was approximated to 203 respondents.

Sampling Technique

A stratified sampling technique was employed to ensure adequate representation of miners from all mining blocks. The study area was divided into four strata based on operational mining blocks, namely Block A, Block B, Block C, and Block D. The stratification was based on the number of registered small-scale miners within each block.

Proportionate Probability Sampling (PPS) was used to allocate the sample size proportionally according to the population size in each block. Thereafter, simple random sampling was used to select individual respondents from the registration lists available in each block.

The total population of registered small-scale miners was 1,000, and the calculated sample size was 203 respondents. Sample allocation was conducted as follows:

Population size in each block × Total sample size

Total population size

- Block A: 150 miners → 30 respondents selected $(150 \times 203)/1000$
- Block B: 500 miners → 102 respondents selected $(500 \times 203)/1000$
- Block C: 50 miners → 10 respondents selected $(50 \times 203)/1000$

- Block D: 300 miners → 61 respondents selected (300 × 203)/1000

Therefore, respondents from each block were selected proportionally to the size of the miner population within that specific block.

Data Collection Procedure and Instruments

Data were collected using a structured, closed-ended questionnaire developed after reviewing previous studies related to silicosis knowledge, attitudes, and preventive practices among miners [10, 11, 16]. The questionnaire consisted of four sections covering socio-demographic characteristics, knowledge, attitudes, and preventive practices regarding silicosis. Knowledge questions assessed awareness of silicosis, causes, symptoms, and preventive measures. Attitude questions were measured using a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Practice questions assessed the use of PPE, dust control measures, training attendance, and medical check-ups.

The questionnaire was prepared in English and translated into Swahili for easier understanding among respondents. Before actual data collection, the tool was pretested among 10% of miners outside the study area to assess clarity, relevance, and consistency of questions. Necessary modifications were made following the pretest. Data collection was conducted by trained research assistants with health science backgrounds. The questionnaires were administered through face-to-face interviews to minimize misunderstanding and improve completeness of responses.

For KAP assessment, correct knowledge responses were scored as “1” and incorrect responses as “0.” Respondents scoring 60% and above were categorized as having adequate knowledge, while those scoring below 60% were categorized as having inadequate knowledge. Attitude scores were categorized into positive and negative attitudes based on mean score values, while preventive practice scores were categorized as good or poor practices using the 60% cut-off point.

Data Analysis and Presentation

The collected data were entered into SPSS version 26 for descriptive analysis to determine the frequency and proportion of demographic data, knowledge, and preventive practices. Attitude was analyzed using a 5-point Likert scale with the lowest value of 1 representing “strongly disagree” and the highest value of 5 representing “strongly agree” [17, 18]. Then results were presented in tables and charts.

RESULTS

Social Demographic Characteristics of Small-Scale Miners

About 84 (41.4%) of respondents were aged group 30-39 years old, while majority of respondents, 202(99%) were male. Regarding education, about 82 (40.4%) of respondents each had either primary or secondary education. Most of the respondents 106 (52.2%) were married. As shown in Table 1.

Table 1: Social Demographic Characteristics of Respondents (N=203)

Variables	Frequency (n)	Percentage (%)
Age		
Under 20	8	3.9
20-29	63	31.0
30-39	84	41.4
40-49	31	15.3
50 and above	17	8.4
Gender		
Male	201	99.0
Female	2	1.0
Level of education		

No formal education	17	8.4
Primary	82	40.4
Secondary	82	40.4
Higher education	22	10.8
Marital status		
Single	56	27.6
Married	106	52.2
Cohabiting	30	14.8
Divorced	8	3.9
Widowed	3	1.5

Knowledge Regarding Silicosis Among Small-Scale Miners

More than half of respondents, 120 (59.1%) have not heard about silicosis. Regarding the causes of silicosis, only 79 (38.9%) knew that silicosis is caused by inhalation of silica dust. About 67 (33.0%) of respondents identify persistent cough as a symptom of silicosis, while only 59 (29.1%) of respondents identified using PPE-like masks as a way to prevent the risk of silicosis as shown in Table 2.

Table 2: Knowledge Among Respondents (N=203)

Category	Frequency (n)	Percent (%)
Heard of silicosis		
Yes	83	40.9
No	120	59.1
Causes		
Inhaling silica dust	79	38.9
Consuming contaminated water	36	17.8
Toxic chemicals	51	25.1
Don't know	37	18.2
Symptoms		
Persistent cough	67	33.0
Joint pain	29	14.3
Skin rash	41	20.2
Don't know	66	32.5
Preventive measures		
Regular hand washing	47	23.2
Using personal protective equipment	59	29.1
Drinking plenty of water	56	27.6
Don't know	41	20.2

Overall Level of Knowledge Regarding Silicosis Among Small-Scale Miners

Overall, approximately 35.5% of respondents demonstrated adequate knowledge regarding silicosis, while 64.5% had inadequate knowledge based on awareness of silicosis, knowledge of causes, symptoms, and preventive measures, as shown in Figure 1.

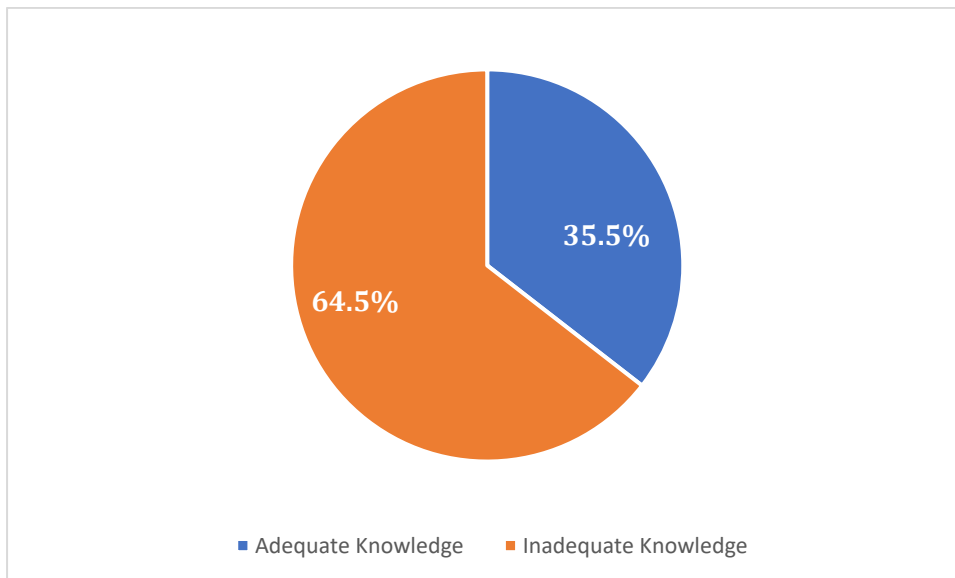


Figure 1: Overall Knowledge Status Regarding Silicosis Among Small-Scale Miners (N = 203)

Overall Attitude Toward Silicosis Prevention Among Small-Scale Miners

Figure 2 shows the overall attitude toward silicosis prevention among small-scale miners. More than half of the respondents, 110 (54.2%), demonstrated negative attitudes toward silicosis prevention, while 93 (45.8%) demonstrated positive attitudes.

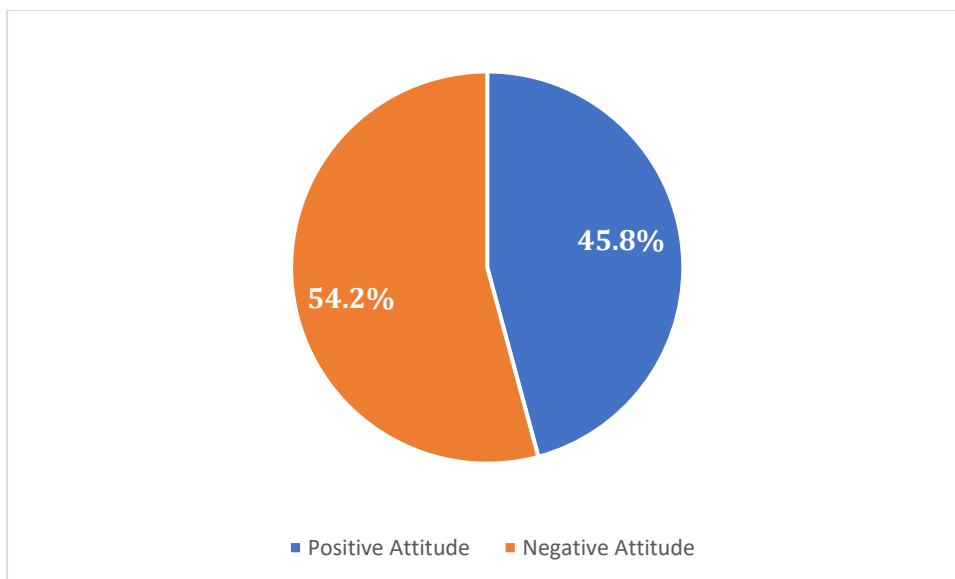


Figure 2: Overall Attitude Toward Silicosis Prevention Among Small-Scale Miners (N = 203)

Attitude Towards Silicosis Among Small-Scale Miners

A considerable portion of respondents remained neutral 65 (32%) on whether silicosis poses a significant health risk. However, about 76 (37.4%) disagree that using PPE is essential for preventing silicosis. A significant portion of respondents 81 (39.9%) were neutral in believing symptoms like coughing or shortness of breath were caused by mining activities. Additionally, only 75 (36.9%) strongly agree with the necessity of training and education on silicosis prevention. only 66 (31%) strongly agreed that following safety measures was important to reduce silicosis risk, as shown in Table 3.

Table 3: Attitude Among Respondents (N=203)

Statement	Attitude response				
	Strongly Disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly Agree n (%)
Believe silicosis poses a significant health risk	23 (11.3)	45 (22.2)	65 (32.0)	23 (11.3)	47 (23.2)
Believe in PPE	0 (0.0)	57 (28.1)	41 (20.2)	29 (14.3)	76 (37.4)
Coughing or shortness of breath are caused by mining activities	8 (3.9)	52 (25.6)	81 (39.9)	16 (7.9)	46 (22.7)
Receiving proper training and education about silicosis prevention is necessary	17 (8.4)	47 (23.2)	51 (25.1)	13 (6.4)	75 (36.9)
Following safety measures is important to reduce the risk of silicosis	32 (15.8)	56 (27.6)	33 (16.3)	19 (9.4)	63 (31.0)

Overall Preventive Practices Regarding Silicosis Among Small-Scale Miners

Overall, approximately 69.4% of respondents demonstrated good preventive practices toward silicosis prevention, while 30.6% demonstrated poor preventive practices, as shown in Figure 3.

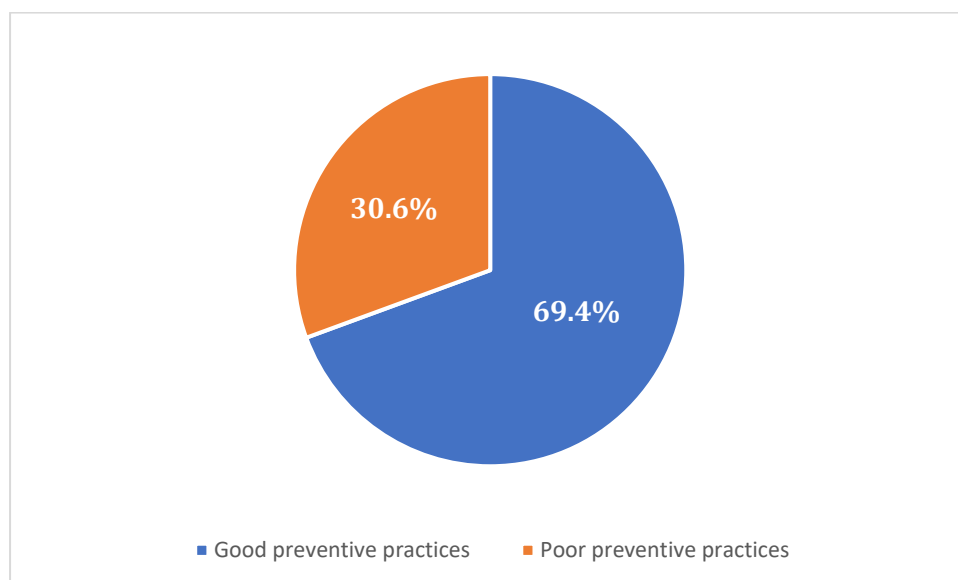


Figure 3: Overall Preventive Practices Regarding Silicosis Among Small-Scale Miners (N=203)

Available Silicosis Preventive Practices Among Small-Scale Miners

The majority of respondents, 137 (67.5%), use masks as their primary PPE, while 135 (66.5%) regularly replace their PPE. Moreover, 160 (78.8%) reported not attending training on preventive measures. Only 66 (32.5%) of respondents undergo quarterly medical evaluations. A significant number, 178 (87.7%), utilized water sprays to reduce dust. Additionally, 174 (85.7%) of respondents address health and safety concerns, as shown in Table 4 below.

Table 4: Silicosis Preventive Practices Among Respondents (N=203)

Variables	Frequency(n)	Percent (%)
Type of PPE		
Masks	137	67.5
Gloves	6	3
Protective clothing	24	11.8

No PPE	36	17.7
PPE replacement		
Regularly	135	66.5
Occasionally	40	19.7
Rarely	9	4.4
Never	19	9.4
Health checks up		
Annually	29	14.3
Semi-annually	43	21.2
Quarterly	66	32.5
Monthly	40	19.7
Never	25	12.3
Measure to reduce dust		
Water sprays	178	87.7
Comfortable clothing	10	4.9
Increase working hours	9	4.4
Use powerful mining equipment	6	3
Training attendance		
Yes	43	21.2
No	160	78.8
Address health and safety concerns		
Yes	174	85.7
No	29	14.3

DISCUSSION

The study found that the majority of respondents had inadequate knowledge regarding silicosis, with about 64.5% showing inadequate knowledge and only 35.5% showing adequate knowledge. More than half of the respondents had never heard about silicosis, while only a few correctly identified inhalations of silica dust as the cause, persistent cough as a symptom, and use of PPE as a preventive measure. These findings differ from the studies conducted in Zambia and Zimbabwe, where most workers were well informed about the health risks related to respirable dust exposure [11, 16]. In the same way, another study from Zimbabwe reported that most respondents knew that silica dust causes permanent and incurable lung diseases [12]. A review study also found that workers who attended awareness campaigns and regular medical check-ups were able to identify important symptoms of silicosis [19]. Likewise, a study in India reported better understanding of preventive measures such as PPE use, wet drilling, and regular health examinations among workers [10]. The low level of knowledge observed in the current study may be linked to limited occupational health education, lack of training, and poor health surveillance among small-scale miners.

Regarding attitude, more than half of respondents had negative attitudes toward silicosis prevention, where 54.2% demonstrated negative attitudes while 45.8% showed positive attitudes. This finding is different from the study conducted in Lesotho, which reported that most respondents had positive attitudes and believed that exposure to crystalline silica dust contributes to occupational lung diseases, including silicosis [13]. Similarly, the study of Nepal found that workers generally had favorable attitudes toward the use of respiratory PPE [20]. In addition, a study from India in Mahesana District reported high acceptance of training and education programs regarding disease prevention among workers [21]. The variation between these findings and the current study may be due to differences in occupational health training, workplace safety programs, and awareness campaigns provided in different settings. Therefore, the current findings indicate the importance of strengthening occupational health education and improving awareness toward

silicosis prevention among small-scale miners.

Although respondents had inadequate knowledge and negative attitudes, the study found that most of them demonstrated good preventive practices, where approximately 69.4% had good preventive practices while 30.6% had poor practices. Most respondents reported using masks as PPE, regularly replacing PPE, using water sprays to reduce dust, and addressing workplace health and safety concerns. These findings differ from the study of Nepal, which reported lower use of respiratory PPE among workers [20]. Likewise, the study from Zimbabwe reported unsafe practices such as using pieces of cloth to prevent dust inhalation and poor dust suppression measures [12]. However, only a few respondents in the present study reported attending preventive training and undergoing regular medical evaluations. Similar findings from a systematic review and modelling study found that many small-scale miners exposed to respirable crystalline silica did not undergo regular medical check-ups, leading to delayed diagnosis of silicosis and related respiratory diseases [9]. The low attendance in training and medical screening observed in the current study could be related to informal employment conditions and limited occupational health services among small-scale miners.

Strengths and Limitations of the Study

This study provides important information regarding knowledge, attitudes, and preventive practices related to silicosis among small-scale miners in Mirerani, Manyara Region. The study focused on small-scale miners, a population that is often underrepresented in occupational health research despite being highly exposed to silica dust. In addition, the use of stratified sampling improved representation of miners from different mining blocks, thereby increasing the reliability of the findings. The simultaneous assessment of knowledge, attitudes, and preventive practices provides comprehensive evidence that may support occupational health interventions and policy formulation for silicosis prevention among small-scale miners.

However, the study relied on self-reported information, which may have been affected by recall bias or social desirability bias among respondents. Furthermore, the study was conducted in one mining area only, which may limit generalization of the findings to all small-scale miners in Tanzania. Despite these limitations, the findings provide useful baseline information for future occupational health research and interventions among small-scale miners.

Conclusion

The findings of this study revealed that small-scale miners at Mirerani had inadequate knowledge and predominantly negative attitudes toward silicosis and its preventive measures. Although several respondents demonstrated good preventive practices such as the use of masks and water sprays for dust suppression, participation in occupational health training and regular medical check-ups remained low. These findings highlight the need for targeted occupational health education and preventive interventions among small-scale miners. Government agencies like Occupational Safety and Health Administration (OSHA) should promote educational campaigns for small-scale miners to raise awareness about silicosis, its causes, symptoms, and prevention. Regular, mandatory training supported by health authorities and mining associations should be implemented to shift attitudes and promote safer mining practices.

DECLARATIONS

Ethical Approval: Research clearance was obtained from the Ruaha Catholic University, while permission to conduct the study was also obtained from the resident Mine Officer of Mirerani Tanzanite Mining.

Informed Consent: Written informed consent was obtained from all participants prior to data collection.

Consent for Publication: Not applicable.

Conflict of Interest: The authors declare no conflict of interest.

Funding: This research received no external funding.

Authors' Contributions: Conceptualization, study design, methodology, resources, data collection, data analysis, and writing the original draft: RJK. Supervision, Review and editing: RRA, JPK.

Data Availability: The datasets generated and analyzed during this study are not publicly available due to ethical and confidentiality restrictions. However, they may be obtained from the corresponding author upon reasonable request, subject to approval by the relevant ethics committee.

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