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Prevalence and determinants of restrictive lung disorder among quarry workers at the Umuoghara quarry site, Ebonyi State, Nigeria: a cross-sectional study

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Abstract

Introduction Respiratory disorders pose a serious health risk for quarry workers exposed to dust, as they are a leading source of morbidity and mortality globally, often resulting in irreversible lung conditions. This study assessed the prevalence and determinants of restrictive disorder among quarry workers in Umuoghara quarry site, Ebonyi State.

Methods This study was done on quarry workers at the Umuoghara quarry site, Ebonyi State. An analytical cross-sectional study design was adopted. Data was collected using a pre-tested semi-structured questionnaire among 300 quarry workers selected by simple random sampling method. Lung function test was performed using a spirometer- spirovit SPI schiller and data was analyzed with the use of IBM SPSS version 23.0. Pearson's chi-square test was used to find associations between variables. Binary logistic regression (multivariate analysis) was used to find the determinants of restrictive lung disorder at $p < 0.05$.

Results The prevalence of restrictive disorder was 14.3%. Working for more than 5 years (AOR = 2.880 at 95% CI = 1.234–6.720), Working for more than 10 years (AOR = 9.645 at 95% CI = 2.601–35.766), smoking (AOR = 3.558 at 95% CI = 1.631–7.762) and non-use of protective measures (AOR = 0.114; 95% CI = 0.050–0.262) were the determinants of restrictive lung disorder in quarry workers.

Conclusion There is an increased risk of developing respiratory problems among quarry workers exposed to quarry dust. It is recommended that employees receive thorough education on the dangers of this exposure, and that employers be mandated to provide protective equipment and strictly enforce its use among workers.

Keywords Predictors, Quarry workers, Restrictive disorder, Spirometry

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Introduction

Working in high-dust environments increases the chance of breathing in particles that could harm one's respiratory system [1]. The inhaled dust particles could cause lung injury as a result of this exposure. Quarry dust carries 71% silica, which on inhalation causes silicosis, an irreversible lung condition in quarry workers [2]. Also, it progresses even after exposure is discontinued [2]. It has been shown that people who work in dusty environments run the risk of breathing particulate matters that may cause respiratory problems such as restrictive disorders. Additionally, there have been reports of a high prevalence of silicosis among Indian quarry employees who work with shale sedimentary rock [3]. Chest pain, catarrh, dyspnea, and non-productive cough were the main respiratory complaints among these quarry employees [3].

There have been numerous reports of significant pulmonary function deficits in quarry workers [3]. A study conducted in Palestine on stone cutters showed that there were 21.6% of cases of abnormal pulmonary function tests, 20.1% of whom had restrictive pulmonary illnesses, and 1.5% of whom had obstructive lung disorders [4]. Predominantly, there was a significant rise in the percentage of workers with abnormal pulmonary function tests as length of exposure increased, with abnormal pulmonary function tests occurring in 16.1%, 20.9%, and 36% of workers with exposure durations of 0–10 years, 11–20 years, and > 21 years, respectively [4].

Prolonged exposure to quarry dust is a major contributor to respiratory problems like restrictive disorders, obstructive disorders, coughing, trouble breathing, and irritation of the airways. According to numerous studies [5.6.7], quarry workers who are exposed to respirable quarry dust are more likely to acquire respiratory conditions. In India, Shrivastava et al. documented cases of respiratory symptoms among exposed stone carvers, and complaints of shortness of breath, cough, and chest pain were present among 26%, 19% and 2% of the workers, respectively [5]. Kabir et al. [6] reported that in Bangladesh, 2.5% of workers in the stone crushing industries experienced restrictive pulmonary disorder. In Brazil, the prevalence of respiratory symptoms among employees was 22.44%, and around 17.69% of workers had reduced pulmonary function as indicated by the spirometer [7]. This study found that workers' lung function reduced and their risk of respiratory impairment increased due to occupational exposure to dust at stone crushing plants.

According to a radiological study, the prevalence of respiratory morbidity among stone quarry workers was 32.5% [8], and the severity of respiratory problems was significantly associated with smoking status, the length of dust exposure, and increasing age [9]. The most likely cause of occupational lung disorders is dust inhalation, which is determined by, the length of exposure, kind of dusts, the size of airborne dust and the concentration. Quarry dust exposure at work may have a number of severe health consequences, including the development of acute respiratory illnesses and deficiencies in the respiratory system. A previous study documented that the pulmonary health impacts of dust exposure on quarry workers were further exacerbated by their inability to wear personal protective equipment, which wasn't provided by their employers [10]. According to a study, 98.3% of quarry workers failed to take the required safety procedures or to wear personal protection [2, 11].

According to the National Institute for Occupational Safety and Health (NIOSH), over 23 million workers in China, 10 million in India, over 3 million in Europe, and 1.7 million in the US are impacted by crystalline silica exposure [12]. Overexposure to crystalline silica dust causes silicosis, a fibrotic lung disease that is frequently categorized as either simple or complicated [13]. While complicated silicosis is linked to the emergence of more severe clinical symptoms, such as dyspnea and respiratory impairment, simple silicosis is not connected with any clinical concerns. Silicosis develops over time at greater exposure values of 200–500 $\mu g/m^3$ [14]. Lower FEV1 (Forced Expiratory Volume in 1 s) and FVC (Forced Vital Capacity) percentages indicate decreased lung functions caused by longer exposure times, as seen in chronic silicosis [15]. The lung function is either restricted or obstructed. The risk of the disease increases with the number of years of dust exposure [15].

Inhalation of crystalline silica triggers macrophage activation in the alveoli. Macrophages attempt to phagocytose the silica particles but fail, leading to cell death and the release of pro-inflammatory cytokines like TNF-α, IL-1β, and reactive oxygen species (ROS). This creates a self-perpetuating cycle of inflammation, tissue damage, and fibrosis, which underlies silicosis. Chronic exposure results in progressive lung fibrosis, contributing to restrictive lung patterns where lung expansion is limited due to stiffened lung tissues [16, 17]. Prolonged inflammation due to silica leads to excessive deposition of extracellular matrix proteins, including collagen, which replaces healthy lung parenchyma. This fibrosis causes decreased lung compliance and reduced total lung capacity, hallmark features of restrictive lung disorders [17]. Over time, nodules form in the upper lung lobes, which can coalesce into larger masses, further restricting lung functionality. Severe cases may progress to progressive massive fibrosis (PMF), associated with more pronounced respiratory impairment [16, 17]. In addition to silicosis, long-term exposure to crystalline silica can cause other respiratory disorders like Sarcoidosis [18, 19] and Idiopathic pulmonary fibrosis (IPF) [18, 20]. Sarcoidosis is a granulomatous disease where the immune system forms clusters of inflammatory cells (granulomas) in response to inhaled silica particles. These granulomas disrupt lung structure, causing stiffness and reduced lung compliance—a hallmark of restrictive lung disorders [19]. Silica exposure amplifies immune reactions, leading to chronic inflammation and fibrosis, a key mechanism of lung restriction [21].

Idiopathic pulmonary fibrosis (IPF) caused by long-term exposure to crystalline silica occurs due to persistent inhalation of fine silica particles, leading to chronic inflammation and fibrosis in the lung's interstitial tissues. The silica particles trigger macrophage activation, releasing pro-inflammatory and fibrotic mediators like transforming growth factor-beta (TGF-β), which drive extracellular matrix deposition and scarring. This scarring restricts lung expansion, contributing to reduced lung compliance and restrictive ventilatory patterns characteristic of IPF [20, 22].

Workers exposed to silica dust, such as those at quarry sites, are at heightened risk of developing these conditions due to chronic, high-dose exposure. This highlights the importance of occupational safety measures and monitoring for early symptoms of respiratory issues.

Although the health effects of working in quarries have been researched in many other nations, they have been comparatively unexplored in Nigeria. This study was carried out to determine the prevalence and determinants of restrictive pulmonary disorder among quarry workers at the Umuoghara quarry site, Ebonyi State.

Methodology

Research objectives

The specific objectives of the study are as follows:

i. To assess the prevalence of restrictive lung disorder among quarry workers in Umuoghara quarry site, Ebonyi state.
ii. To ascertain the determinants of restrictive lung disorder among quarry workers in Umuoghara quarry site, Ebonyi State.

Study design

An analytical cross-sectional design was adopted in this study.

Study setting

The study was conducted at a stone crushing quarry site located at the Umuoghara community in Ezza North Local Government Area of Ebonyi State, Nigeria, which was chosen for its accessibility to the target population of study. The geological formation of the area is characterized predominantly by granite, which is known to release silica dust during crushing processes. The duration of the study was two weeks to allow for adequate data collection and analysis.

Study population

Adults (≥ 18years) male and female workers engaged in the crushing process, who have worked in the quarry for at least one year. The choice of workers who have had at least one year of experience is to allow for sufficient time of exposure to quarry dust, in order to determine its effect on lung function and respiratory health. However, those absent or on leaves during the period of study were excluded.

Sampling technique

The crusher's union register was the sampling frame. The study population was about one thousand two hundred and fifty people (1,250). A simple random sampling method was applied to select the subjects using table of random numbers. The minimum sample size was determined using existing prevalence rate of abnormal lung function (23.0%) [23], a precision of 5% and the formulae: $n = z^2pq/d^2$.

Where: n = Sample Size; Z = Z-value (1.96 for a 95% confidence level); P = the proportion of prevalence in the population, i.e. 23.0% or 0.230 [23]; $q = 1 - p = 1–0.230 = 0.770$; d = degree of accuracy desired = 0.05; n is the minimum sample size = 272. To improve precision and cover for non-response rate, a total of 300 workers were studied.

Data collection tools and methods

The tools used for measurement include a spirometer-spirovit SPI schiller [Switzerland], weighing scale, non-stretchable metric tape rule and questionnaires.

The measurements taken included forced vital capacity (FVC) in liters, forced expiratory volume in one second in liters, age in years, height in cm and weight in kg. The weight of each subject was recorded in kilograms with the subject wearing light clothing and without shoes. A portable bathroom weighing scale was used. The standing height of each subject was measured in centimeters with a non-stretchable metric tape.

Lung Function Test; With the subject seated on a straight back chair and the belt loosened, they took in as deep a breath as possible, applied their lips firmly around the mouth piece so that there would be no air leakage and then breathed out as quickly, forcefully, and as completely as possible into the spirometer with the nose clipped. While the subject was doing this, a check was made for air leakage around their mouth piece, and if it was detected, the blow was repeated. Each subject performed three blows. There was an interval of 5 min between each blow to allow the subject to regain equilibrium. Forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), ratio of (FEV1) to (FVC), height and weight were the parameters that were measured for the lung function test. Forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) measurements were obtained for all the subjects in the same sitting position using the spirometer. Each subject performed the test three times, and the highest values were selected.

Normal spirometry indicates that all measured parameters (FVC, FEV1, and FEV1/FVC) are 80% or higher than the predicted values compared to their sex, age, height, weight, and ethnicity [24]. It was determined using the Global Lung Initiative (GLI-2012) reference equation for African Americans, which is used to determine the severity of lung function abnormalities (normal/abnormal) [25]. An obstructive pattern means that FEV1 is lower than 80% of the predicted value, FVC is reduced but to a lesser extent than FEV1, and the ratio is also reduced to lower than 70% [24]. A restrictive pattern means that both FEV1 and FVC are reduced to lower than 80% of the predicted value, and the ratio is normal (above 70%) [24].

The questionnaire; a semi-structured questionnaire developed by the researcher based on the objectives of the study was used. The questionnaire consisted of open-ended questions, which were arranged in four sections, A, B, C, and D. Section A contained questions that elicited responses on the demographic data of the respondents; section B contained questions on factors associated with respiratory problems; section C contained questions on knowledge of workplace hazards, safety measures and practices; and section D comprised a physical examination and lung function test.

Instrument validation and data collection

Pre-testing of the tools was done among non-participating quarry workers. Also, a draft copy of the questionnaire was scrutinized by the supervisor to rule out ambiguity and ensure that the questions actually measured the objectives of the study. These also ensured face and content validity of the questionnaire. The corrections and necessary adjustments were made by the researcher. After validation of the questionnaire, it was interviewer administered to the study population. Data collection was done by the researcher and research assistants who were rigorously trained for two days on the data collection tools. The questionnaires were administered at the quarry site in batches for a period of 5 days.

Data management and analysis

All questionnaires were stored in locked cabinets throughout the study and accessed only by the researcher to ensure confidentiality and to avoid data loss. After data collection, double entry of the same data was done for accuracy purposes. The data was entered into Microsoft Excel and stored in the computer under a password. Data cleaning was performed, whereby missing values, extreme values and inconsistencies were identified and corrected. After cleaning, the data was then exported to IBM SPSS software version 23.0 for analysis. The data was cleaned and then exported to IBM SPSS version 23.0 for further analysis. Tables displaying the frequency distribution for the independent and dependent variables were used to present the data. IBM SPSS version 23.0 was used to analyze the data. Descriptive analysis was done using means, proportions and frequencies. Pearson's chi-square test was used to determine associations between variables. Binary logistic regression (multivariate analysis) was used to find the determinants of respiratory problems and abnormal lung function. A p-value of < 0.05 was considered statistically significant.

Measurement of variables

The presence of chronic obstructive pulmonary disorder (COPD) was determined by reduced FEV1 (< 80% of the predicted normal) and FEV1/FVC ratio of < 70%; and absence was determined by Normal FEV1, FVC and FEV1/FVC ratio of $\geq$ 70%.

For restrictive disorder: The presence was determined by reduced FEV1 and FVC (< 80% of the predicted normal) and an FEV1/FVC ratio of $\geq$ 70%, and absence was determined by a normal FEV1, FVC and an FEV1/FVC ratio ≥ 70%.

Ethical considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval for the study was obtained from the Health Research Ethics Committee (HREC) of the University of Nigeria Teaching Hospital (UNTH), Ituku-Ozalla, Enugu. Additionally, written consent was obtained from all the participating subjects, and their confidentiality was guaranteed through the use of anonymous questionnaires (by coding their identities). These subjects were also informed of their freedom to withdraw from the research at any point in the study if they wished. Before testing, the purpose of this test was explained again to each subject, and the method of testing was demonstrated by the researcher.

Results

Table 1 shows the demographic characteristics of the respondents. Higher proportion of the subjects were $\leq$ 34 years (68.3%), males (66.7%), Nigerian (90.0), and had primary education and below (53.0%). The mean and standard values of age, height and weight were 31.6 ± 11.5 years, 158.7 ± 8.95 cm and 59.0 ± 13.85 kg, respectively.

Table 2 shows the distribution of quarry workers by exposure, smoking, past medical history and use of protective measures. About 137 (45.7%) respondents had a work experience of $\leq$ 5 years, 143 (47.7%) had a work experience of > 5 to 10years, and 20 (6.6%) had a work

Table 1 Socio-demographic characteristics of Umuoghara quarry site workers

Characteristics	Frequency ($n=300$)	Percentage (%)
Age(years)		
$\leq$ 34	205	68.3
$>$ 34	95	31.7
Mean $\pm$ ***SD***	***31.6*** $\pm$ ***11.5***	
Mean Height (cm) $\pm$ ***SD***	***158.7*** $\pm$ ***8.95***	
Mean Weight (kg) $\pm$ ***SD***	***59.0*** $\pm$ ***13.85***	
Gender		
Male	200	66.7
Female	100	33.3
Nationality		
Nigerian	270	90.0
Others	30	10.0
Educational Qualification		
Primary and below	166	55.3
Secondary	124	41.3
Tertiary	10	3.3

Table 2 Distribution of quarry workers by exposure, smoking, past medical history and use of protective measures

Variable	Frequency($n=300$)	Percentage (%)
Duration of exposure(in years)		
$\leq$ 5 years	137	45.7
> 5years – 10years	143	47.7
> 10 years	20	6.6
Smoking habit		
Never smoked	211	70.3
Currently smoking	77	25.7
Previously smoked	12	4.0
Past history of respiratory illness		
Yes	17	5.7
No	283	94.3
Use of protective measures		
Used	101	33.7
Did not use	199	66.3
Exposure to dust/smoke from previous jobs		
Yes	37	12.3
No	263	87.7

experience of >10years. The lowest duration of work experience was 1 year and the highest was 20 years. Additionally, 89 (29.7%) currently/previously smoked, and 17 (5.7%) had a past history of chronic respiratory illness. Also, 37 (12.3%) of the respondents had previously been exposed to dust/smoke from other jobs and majority of the respondents (66. 3%) did not use any protective measures while working in the quarry.

Table 3 shows the distribution of lung function in quarry workers. The mean values of FEV1 and FVC in liters was 2.13 ± 0.50 and 2.50 ± 0.77 respectively. The mean values of FEV1/FVC ratio in % was 85.20 ± 7.73. The mean value of FEV1 (predicted %) was 84.86 ± 12.00 while FVC (predicted %) was 87.39 ± 12.63.

According to these spirometric results, 75 (25%) of the respondents had abnormal lung function, out of which 43 (14.3%) had restrictive disorder.

Table 4 shows predictors of restrictive lung disorder. Age ($\chi^2 = 11.046$, $p = < 0.001$), duration of exposure ($\chi^2 = 11.123$, $p = 0.004$)), smoking habits ($\chi^2 = 26.394$, $p = < 0.001$), and use of protective measures ($\chi^2 = 33.188$, $p = < 0.001$) were significantly associated with the presence of restrictive lung disorder.

Respondents who had worked for more than 5 years were about 2.8 times (AOR = 2.880 at 95% CI = 1.234–6.720) more likely to have restrictive lung disorder than those who had worked for less than 5 years. Respondents who had worked for more than 10 years were about 9.6 times (AOR = 9.645 at 95% CI = 2.601–35.766) more likely to have restrictive lung disorder than those who had worked for less than 5 years. Respondents who had smoked were about 3.5 times (AOR = 3.558 at 95% CI = 1.631–7.762) more likely to have restrictive lung disorder than non-smokers. Those who used protective measures while working in the quarry were significantly less likely (AOR = 0.114 at 95% CI = 0.050–0.262) to have restrictive lung disorder those that did not use protective measures.

Discussion

The study revealed that a significant proportion (14.3%) of quarry workers had restrictive pulmonary disorder. This may be as a result of prolonged exposure to quarry dust, poor use of protective measures as well as other factors. This is consistent with a study done in Kenya [23] on quarry workers which reported restrictive disorder to be 12.7%. However, there is some variance in the prevalence of restrictive disorder across other studies globally, reflecting differences in occupational practices, exposure levels, and regional health and safety measures. For instance, in a study in Bangladesh, only 2.5% had restrictive pulmonary disorders [6]. The reason may be because in the Bangladesh study [6] it was revealed that most (95.3%) of the quarry workers had a work experience of less than 5 years but in this study a higher percentage of the quarry workers had over 5 years of work experience hence higher prevalence of restrictive disorder because of longer duration of exposure.

In contrast, a study in Wardha District, India, reported a significantly higher prevalence of 31.04% [26], highlighting the variation in risk factors and exposure levels across regions. Similarly, in Pakistan [27], 34% of workers exposed to crystalline silica in marble dust had restrictive pulmonary impairment, reflecting the hazardous nature

Table 3 Distribution of lung function in quarry workers

Lung function of the respondents		
Forced Expiratory Volume at first second FEV1 (liters)	2.13 ± 0.50	
Forced Vital Capacity FVC (liters)	2.50 ± 0.77	
FEV1/FVC ratio (%) (FEV1/FVC * 100)	85.20 ± 7.73	
FEV1 (predicted %)	84.86 ± 12.00	
FVC (predicted %)	87.39 ± 12.63	
	Frequency (n = 300)	**Percentage (%)**
FEV1 (predicted %)		
Normal (≥ 80%)	214	71.3
Abnormal (< 80%)	86	28.7
FVC (predicted %)		
Normal (≥ 80%)	237	79.0
Abnormal (< 80%)	63	21.0
FEV1 / FVC%		
Normal (≥ 80%)	248	82.7
Abnormal (< 80%)	52	17.3
Chronic Obstructive Pulmonary Disorder (COPD)		
Present	32	10.7
Absent	268	89.3
Restrictive Disorder		
Present	43	14.3
Absent	257	85.7

Table 4 Determinants of restrictive lung disorder

Socio-demographic characteristics		**Bivariate analysis**			**Multivariate analysis**
		Restrictive disorder (*n* = 300)		**X^2 (*p* value)**	**AOR (95% CI)**
		Present (*n* = 43) *n*(%)	**Absent (*n* = 257) *n*(%)**		
Age	≤ 34	20(9.8)	185(90.2)	***11.046***	
	> 34	23(24.2)	72(75.8)	***(< 0.001)***	2.094 (0.953–4.602)
Gender	Male	26(13.0)	174(87.0)	***0.869***	
	Female	17(17.0)	83(83.0)	***(0.351)***	**NA**
Nationality	Nigerian	41(15.2)	229(84.8)	***1.873***	
	Others	2(6.7)	28(93.3)	***(0.171)***	**NA**
Education	Primary and below	19(11.4)	147(88.6)	***2.524***	
	Secondary and above	24(17.9)	110(82.1)	***(0.112)***	**NA**
Duration of exposure (in years	≤ 5 years	12(8.8)	125(91.2)	**11.123**	
	> 5years – 10years	24(16.8)	119(83.2)	**(0.004)**	2.880 (1.234–6.720)
	> 10years	7(35.0)	13(65.0)		9.645 (2.601–35.766)
Smoking habits	Have smoked	27(30.3)	62(69.7)	**26.394**	
	Never smoked	16(7.6)	195(92.4)	**(< 0.001)**	3.558 (1.631–7.762)
Past history of respiratory illness	Yes	1(5.9)	16(94.1)	**1.048**	
	No	42(14.8)	241(85.2)	**(0.306)**	NA
Use of protective measures	Used	31(30.7)	70(69.3)	**33.188**	
	Did not use	12(6.0)	187(94.0)	**(< 0.001)**	0.114 (0.050–0.262)
Exposure to dust/smoke from other jobs	Yes	7(18.9)	30(81.1)	**0.723**	
	No	36(13.7)	227(86.3)	**(0.395)**	NA

of silica dust exposure and possibly differing levels of protective measures or work conditions.

Other studies also support the significant burden of restrictive disorders among quarry workers exposed to respirable silica dust. A study in Iran [28] on agate grinding workers revealed a prevalence of 24.3% for restrictive impairments, which the authors attributed to shorter work durations and lower cumulative exposures. Similarly, a study in Palestine and Peshawar among stone-cutting/crushing workers reported a prevalence of 20.1%

[29], and 23.3% [30] respectively. These results emphasize that while restrictive lung disorders are a prevalent issue in quarrying operations across different regions, the specific prevalence rates are influenced by variations in dust type, concentration, cumulative exposure, and the effectiveness of safety interventions.

These comparisons illustrate that while restrictive pulmonary disorders are a significant health issue for quarry workers worldwide, the prevalence rates are influenced by factors such as dust type, concentration, cumulative exposure, and the effectiveness of occupational safety interventions. This underscores the importance of implementing region-specific occupational health policies, improving the use of protective equipment, and conducting regular health monitoring to mitigate risks.

By situating the findings within a broader context, this study contributes to a deeper understanding of the global landscape of respiratory health challenges in quarry industries. Furthermore, it highlights the long-term implications of restrictive pulmonary disorders, which can lead to significant lung tissue damage during employment and after retirement.

The findings of this study equally showed that duration of exposure, smoking and use of protective measures were the factors that significantly influenced the presence of restrictive lung disorder. Quarry workers continuing to work for so many years despite the detrimental effect of quarry dust may be because the quarry is one of the few industries in the state that offers sustainable jobs. Working in a quarry for a longer period of time leads to a higher risk of developing restrictive disorder which can result in long term health complications. On duration of exposure; this finding is similar to many other researches [2, 6, 31–36]. According to a radiological study, the prevalence of respiratory morbidity among stone quarry workers was 32.5%, and the severity of respiratory problems was significantly associated with the length of dust exposure [10]. A similar study reported there was a significant rise in the percentage of workers with abnormal pulmonary function tests as length of exposure increased, with abnormal pulmonary function tests occurring in 16.1% of workers for 0–10 years, 20.9% for 11–20 years, and 36% of workers for >21 years [4]. This implies that Lung impairment increased with increasing duration of exposure to dust in years among the quarry workers.

For smoking; this is similar to a study done on stone quarry workers in Namibia [13] which showed that quarry workers who smoked had a higher risk of having restrictive lung disorder than nonsmokers. In contrast, a study done in India [26] on stone quarry workers showed no significant association between smoking and restrictive disorder. The findings of this study suggest that quarry workers who are smokers are more likely to have restrictive lung disorder than non-smokers. According to a study, the severity of respiratory problems was significantly associated with smoking status [10]. Most quarry workers (92.5%) were current smokers. FEV1 showed the strongest correlation with smoking history after adjusting for dust exposure. Each additional pack-year of smoking was associated with a further decline in FEV1 [6, 32, 36].

This study reported a significant association between use of protective measures and the presence of restrictive disorder. This may be because of poor working conditions in the quarry; workers may find it uncomfortable to use a protective equipment while working under the sun. This finding is similar to a study done in India on stone quarry workers [37]. This study indicates that quarry workers who used protective measures while working in the quarry are less likely to have restrictive lung disorder those that did not use protective measures. According to a study, the pulmonary health impacts of dust exposure on quarry workers were further exacerbated by their inability to wear personal protective equipment, which wasn't provided by their employers [10]. According to a study, 98.3% of quarry workers failed to take the required safety procedures or to wear personal protection [2, 11]. It underlines the importance of proper education of the quarry workers on the use of protective measures while working. The quarry workers were provided with hard hats, nose masks and eye protection. Compliance with protective measures was low due to poor working conditions in the quarry, such as high temperatures and exposure to the sun, which made wearing protective equipment uncomfortable. Additionally, the quantity of protective equipment, including nose masks and eye protection, was insufficient to go around, leading to inconsistent use. To improve compliance, future initiatives could focus on providing more comfortable, breathable protective equipment designed for hot working environments, such as lighter nose masks. Additionally, incorporating more frequent breaks in shaded or cool areas could help workers manage the discomfort of working under the sun while maintaining their safety.

This study exhibits several strengths and limitations across its research framework. A major strength is its focus on a crucial public health concern by determining the prevalence and contributing factors of restrictive lung disorders in quarry workers, providing essential insights into the predictors of respiratory diseases. Additionally, the application of advanced statistical tools, like multivariate regression, facilitated the analysis of the distinct effects of individual factors while accounting for confounding variables. The study's consistency with existing research further enhances its contribution to occupational health knowledge.

Nevertheless, certain limitations exist. One primary concern is the dependence on self-reported information, especially regarding the use of protective equipment and smoking habits, which may introduce recall bias. Participants may either overestimate or underestimate their behaviors, which can affect the accuracy of the data. To mitigate recall bias in future studies, we suggest incorporating direct observation or biometric data collection. Direct observation allows researchers to assess behaviors in real-time, reducing the reliance on participants' memory. Additionally, using objective measures such as wearable devices or biomarkers (e.g., nicotine levels in blood or saliva) can provide more accurate data on smoking habits and the use of protective equipment. Moreover, the study's cross-sectional design lacks the ability to monitor disease progression over time. Future studies could overcome this limitation by employing a longitudinal approach. Furthermore, the absence of chest radiography is another limitation. Spirometry, while a valuable tool for assessing lung function, may not always detect the full extent of structural changes or damage to the lungs, particularly in cases of restrictive lung disorders. Chest radiography can help identify structural abnormalities or other lung pathologies that spirometry alone might miss, enabling a more thorough evaluation of lung function and health. Incorporating radiographic assessments in future research would offer a more thorough evaluation of respiratory conditions such as this.

Conclusion

The prevalence of restrictive pulmonary disorder was significant among quarry workers. The factors that determined the presence of restrictive disorder were duration of exposure, smoking, and use of protective measures. The findings in this study suggest the need to raise awareness on respiratory health problems of workers at stone crushing industries in Nigeria. It will also encourage the government to make policies for the prevention, control, and elimination of silica exposure, thereby enhancing public health policy and practices in the country.

Abbreviations

COPD	Chronic obstructive pulmonary disorder
FEV1	Forced Expiratory Volume in 1 s
FVC	Forced Vital Capacity

Supplementary Information

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Supplementary Material 1

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Author contributions

This study was carried out in collaboration among all authors. Author NSI conceptualized the study, designed the study, carried out data collection, statistical analysis and compiled the tables. Author NSI and OCE wrote the study protocol. NSI, OCE, and SCU wrote and compiled the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval for the study was obtained from the Health Research Ethics Committee (HREC) of the University of Nigeria Teaching Hospital (UNTH), Ituku-Ozalla, Enugu. Additionally, written informed consent was obtained from all the participating subjects, and their confidentiality was guaranteed through the use of anonymous questionnaires. To ensure voluntary participation, all participants were fully informed about the purpose of the study, the procedures involved, and their right to withdraw at any time without any negative consequences, including potential repercussions for their employment. Informed consent forms were provided in clear language, and participants were encouraged to ask questions and seek clarification before agreeing to take part. We emphasized that participation was entirely voluntary and that non-participation would not affect their employment status or relationships with management. To further protect participants' privacy, all data collected was kept confidential. Personal identifiers were removed from the data, and a unique code was used for each participant. All data were stored securely in password-protected files, and only authorized personnel had access to the data. Participants' names and other identifiable information were never shared with third parties, ensuring the highest levels of confidentiality throughout the study. Additionally, ongoing support was provided throughout the study to address any concerns or discomfort. An ethical clearance certificate is attached as a supplementary file.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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