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Pulmonary Problems among Quarry Workers of Stone Crushing Industrial Site at Umuoghara, Ebonyi State, Nigeria

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Abstract

Background: Respiratory problem is one of the major health hazards in dust-exposed workers; it is a major cause of morbidity and mortality all over the world.

Objective: To determine the prevalence of respiratory problems and lung function impairment among quarry workers in Ebonyi State, Nigeria.

Methods: Respiratory problems and lung function were studied in 403 quarry workers aged 10–60 years. Respiratory problems were investigated with a questionnaire based on international models adapted for the study population. Lung function was assessed by spirometry and chest roentgenography.

Results: The respiratory problems found were chest pain (47.6%), occasional cough (40.7%), occasional shortness of breath (6.5%) and wheezing (5.2%). The mean±SD FEV₁ and FVC values were significantly decreased with length of exposure—respectively, 3.52±0.77 and 3.91±0.72 L for <5 years; 2.79±0.68 and 3.09±0.87 L for 5–10 years; and 2.03±0.92 and 2.86±0.83 L for >10 years of exposure. Moreover, the mean±SD FEV₁ and FVC values of smoker (3.37±0.81 and 3.56±1.02 L, respectively) were significantly ($p<0.05$) lower than that of non-smokers (3.68±1.02 and 3.89±0.99 L, respectively) working in the quarry site.

Conclusion: Chronic exposure to dust due to stone quarrying may increase the risk of respiratory problems and impaired lung function—cigarette smokers are at higher risk.

Keywords: Occupational exposure; Signs and symptoms, respiratory; Silicosis; Respiratory function test

Introduction

Occupational exposure to dust is a well-known phenomenon, especially in developing countries.^{1,2} Although sources of air pollutants include power plants, cement factories, refineries

and petrochemical industries, the emission of particulates is quite high from quarries.³ The health impacts of working in stone quarrying industry have been well documented.^{4,5} For instance, numerous epidemiological studies have supported the association between respiratory

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Received: Mar 27, 2012
Accepted: May 21, 2012

Cite this article as: Nwibo AN, Ugwuja EI, Nwambeke NO, et al. Pulmonary Problems among Quarry Workers of Stone Crushing Industrial Site at Umuoghara, Ebonyi State, Nigeria. *The International Journal of Occupational and Environmental Medicine* 2012;3:178-185.



impairment and occupational exposure to dust.⁴ Again, individuals working in dusty environment have been found to carry the risk of inhaling particulate materials (*e.g.*, silica) that may lead to adverse respiratory effects,⁶ such as chronic bronchitis, emphysema, acute and chronic silicosis, lung cancer, *etc.*,⁷ which are disabling and can even be fatal. Also, high prevalence of silicosis has been reported among workers engaged in quarrying shale sedimentary rock in India. According to Urom, *et al*,⁸ the major respiratory symptoms among quarry workers include non-productive cough, chest pain, catarrh and dyspnea. Considerable pulmonary function impairments have been reported in quarry workers.^{9,10} In a study by Ghotkar, *et al*,¹¹ the prevalence of respiratory morbidity among stone quarry workers was 32.5%, based on radiological study; the severity of pulmonary function impairment was significantly associated with increasing age, duration of exposure to dust, smoking status and presence of chronic obstructive airways disease on radiological study. It was shown that dusts generated from granite quarrying contain 71% silica.^{12,13} The occupationally related lung diseases are most likely due to the deposition of dust in the lung and are influenced by the type of dusts, the period of exposure, the concentration and the size of the airborne dust in the breathing zone.¹⁴ In Nigeria stone quarrying represents an unorganized sector of industry. Quarrying products are increasingly demanded for industrial, domestic, agricultural and other purposes to satisfy the needs of the rapidly growing population.³ The industry in Ebonyi State employs at least 1000 workers, both men and women, aged between less than 10 and 60 years. The fact that no specific professional training is required and the high level of unemployment currently prevailing in Nigeria, have encouraged all categories of people, in-

cluding under-aged children, young women of child-bearing age and even pregnant women, to get involved in quarrying, irrespective of the associated health hazards. To the best of our knowledge, the health implications of continuous exposure to stone dust have not been studied among quarry workers in Abakaliki.

Considering the fact that quarry industry has become one of the major employers of labour as well as the means of livelihood for many people in State, Nigeria, we therefore conducted this study to determine the prevalence of respiratory problems and impaired lung functions among quarry workers of stone crushing industrial sites in Umuoghara Ebonyi state. We also tried to document the availability of health care facilities and safety measures at the site as ways of minimizing occupational health hazards associated with stone quarrying.

Materials and Methods

This cross-sectional study was conducted in stone crushing site located at Umuoghara community in Ezza North Local Government Area of Ebonyi State, Nigeria. Male and female workers aged 10 to 60 years who had worked at the site for one year or more, were included in the study. Workers with clinical abnormalities of vertebral column and thoracic cage, anemia, diabetes mellitus, hypertension, pulmonary tuberculosis, bronchial asthma, chronic bronchitis, emphysema and other respiratory diseases and subjects who had undergone abdominal or chest surgery were excluded from the study.¹⁵

Cluster sampling method was used. The quarry workers organized themselves in clusters within the stone crushing industrial site. Five clusters were randomly selected from 10 clusters that made up the site using simple random sampling method. In each of the selected clusters,

TAKE-HOME MESSAGE

- In Nigeria, quarrying products are increasingly demanded for industrial, domestic, agricultural and other purposes to satisfy the needs of the rapidly growing population.
- Individuals working in dusty environment have been found to be at risk of inhaling particulate materials (e.g., silica) that may lead to adverse health effects.
- Chronic exposure to dust from crushing of rocks may increase susceptibility to respiratory problems and impaired lung function with tobacco/cigarette smoking and increased length of service as additional predisposing risk factors.
- The occupationally related lung diseases among quarry workers are most likely due to the deposition of dust in the lung and are influenced by the type of dusts, the period of exposure, the concentration and size of the airborne dust in the breathing zone.

every member was fully interviewed/investigated.

The data collection instruments included questionnaire (self- and interviewer-administered), spirometry and radiological studies. The questionnaire used was semi-structured, comprising of three parts (A, B, C) and containing a total number of 19 questions; the three parts were used to capture data relating to socio-demographic characteristics, medical history, and respiratory problems, respectively. The language of the original questionnaire was English. The questionnaire was sent to an Igbo language expert for translation and then back-translated

into English. The administration was done in Igbo language. The study instruments were pre-tested on 50 Ebonyi State indigenes resident in Ezzamgbo. Pre-testing of the study instruments was done to determine their suitability, ensure clarity, eliminate ambiguity and ascertain the length of time required for administration and answering of questions. The functionality of the peak flowmeter was pre-tested according to the manufacturer's instruction.

Approval of the protocol for this study was obtained from the Ethical Committee of Nnamdi Azikiwe University Teaching Hospital-Nnewi, leadership of the Stone Crushing Industrial Site, Umuogbara, Famers' Association, Ezzamgbo, as well as the Directorate of Public Health Services, Ministry of Health, Ebonyi State. Written informed consent was obtained from all the participants.

A total of 403 quarry workers, including men and women aged between 10 and 60 years were entered the study. They were then grouped into four groups, depending on the number of years each worker had spent working in the quarry industry (i.e., the duration of exposure to the quarry dust): group 1 had <5 years of exposure; group 2 had 5–10 years; group 3 had 10–15 years; and group 4 had >15 years of exposure. All groups were investigated for respiratory problems, past history of respiratory diseases, and lung functions. The participants were also evaluated by radiography. Respiratory symptoms and past history of pulmonary diseases were investigated with a structured questionnaire based on international models (pre-tested for understanding of the study population). The workers were interviewed on each day before the beginning of their daily shift (morning or afternoon).

In addition to the questionnaire, respiratory problems and past history of

For more information on the effects of silica exposure see www.theijoem.com/ijoem/index.php/ijoem/article/view/5/22

For more information on inhalational lung disease see www.theijoem.com/ijoem/index.php/ijoem/article/view/4/21

lung diseases were also investigated by a through medical examination (health history and physical examination). Lung function impairment was investigated with spirometry and chest x-rays. The spirometry was carried out using a calibrated portable spirometer (Micro Peak, UK). Spirometry was done with participants sitting at an ambient room temperature; the subjects were asked to exhale into the spirometer as forcefully as possible after maximum inspiration. The test was repeated three times after adequate rest and the highest reading was used. The parameters measured were forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁). The chest x-ray was carried out through the assistance of a trained radiographer and interpreted by a qualified radiologist.

Statistical analysis

The data collected was analyzed with SPSS® for Windows® ver 16.0 (SPSS Inc., Chicago, IL, USA). Independent sample *Student's t* test was used to compare means between two groups. A $p < 0.05$ was considered statistically significant.

Results

The mean±SD age of the study population was 30.1±9.3 years. Table 1 shows the general characteristics of the subjects. Majority of the workers were stone breakers (40.0%) and loaders (30.3 %); both sexes were equally engaged in stone quarrying (51.6% male and 48.4% female); higher proportions of the workers were married (58.3%). While only one subject was found to have no formal education, majority of the workers had primary (40.2%) and secondary (49.1%) education with 10.2% of the workers educated to the tertiary education level. Majority of the quarry workers were fully engaged (96.3%)—3.7% were part-time.

Table 1: General characteristics of quarry workers at Umuoghara stone quarrying industrial site

Parameters	n (%)
Job designation	
Breaking of stones	161 (40.0)
Loading stones	122 (30.3)
Grinding stones	78 (19.3)
*Others	42 (10.4)
Total	403 (100)
Sex	
Male	208 (51.6)
Female	195 (48.4)
Total	403 (100)
Marital status	
Single	168 (41.7)
Married	235 (58.3)
Total	403 (100)
Educational level	
None	1 (0.3)
Primary	162 (40.2)
Secondary	198 (49.1)
Tertiary	42 (10.4)
Total	403 (100)
Mode of employment	
Full-time	388 (96.3)
Part-time	15 (3.7)
Total	403 (100)
*Including supervisors, drivers and sales boys/girls	

The respiratory problems and availability of medical care and use of safety measures are presented in Table 2. The major respiratory problems recorded were occasional chest pain (47.6%), and occasional cough (40.7%); 0.5% had

Table 2: Incidence of respiratory problems among quarry workers, availability of medical care at quarry industrial site, and use of safety measures by the quarry workers

Parameters	n (%)
Respiratory problems	
Occasional chest pain	191 (47.4)
Occasional cough	163 (40.5)
Wheezing	21 (5.2)
Shortness of breath	26 (6.4)
Sputum mixed with blood	2 (0.5)
Total	403 (100)
Availability of medical care and use of safety measures	
No medical care	403 (100)
No safety measures	396 (98.3)
Use of face mask	3 (0.7)
Use of apron	2 (0.5)
Use of other devices	2 (0.5)
Total	403 (100)

sputum mixed with blood. Information on the availability of medical care in the quarry industrial site and use of safety measures by the quarry workers revealed total absence of a medical center in the study area. Almost all the quarry workers (98.3%) used no self-protective devices—only 0.5% used either apron or other protective devices while working.

FEV₁ and FVC values of the study population stratified by age, sex, length of service and smoking habit are shown in Table 3. Although both FEV₁ and FVC seem to be higher in the younger age groups in comparison with the older participants, the difference was not statistically significant. Also there was no statistically sig-

nificant sex difference in the mean FEV₁ and FVC, although the values were higher in women than men.

Most of the workers (80.6%) had worked for less than five years at the site—only 1.7% had worked more than 10 years. After adjusting for age, sex and height, the length of working at the site had significant ($p < 0.05$) suppressing effects on both FEV₁ and FVC, with workers exposed for less than five years having mean \pm SD FEV₁ of 3.52 ± 0.77 L and FVC of 3.91 ± 0.72 L, while those exposed for more than 10 years had mean \pm SD FEV₁ of 2.03 ± 0.92 L and FVC of 2.86 ± 0.83 L (Table 3). The mean \pm SD FEV₁ and FVC values for smokers (3.37 ± 0.81 L and 3.56 ± 1.02 L, respectively) were also significantly ($p < 0.05$) lower than those of their non-smoker counterparts (3.68 ± 1.02 L and 3.89 ± 0.99 L, respectively). FEV₁ had a significant inverse correlation ($r = 0.198$, $p < 0.05$) with respondent exposure time, but not with age ($r = 0.079$).

About one-third of the quarry workers had one form of radiological abnormalities (Table 4)—67.5% had normal radiological findings. A reasonable proportion (3.7%) of participants had hepatomegally.

Discussion

We found that more than 96% of the participants were working in the quarry industrial site on a full-time basis, indicating that majority of them are at a high risk of exposure to the respirable quarry dust. Moreover, almost 10% of the respondents had tertiary level education, suggesting a low level of awareness of the respondents about the health implications of the respirable quarry dust. Men and women (including some pregnant women) were almost equally distributed within the quarry workers—58.3% were married. The fact that married women of reproductive age take part in this type

Table 3: Pulmonary functions of quarry workers in relation to age, sex, length of service and smoking habit

Parameter	n (%)	Mean±SD (L)	
		FEV ₁	FVC
Age groups (yrs)			
≤10	1 (0.2)	2.33±0.68	2.89±0.79
11–20	53 (13.2)	2.04±0.88	2.79±0.60
21–30	171 (42.4)	2.10±0.73	1.90±0.72
31–40	132 (32.8)	1.98±0.78	1.89±0.68
>40	46 (11.4)	1.95±0.65	1.98±0.60
Sex			
Male	208 (51.6)	2.34±0.67	2.88±1.01
Female	195 (48.9)	2.68±0.76	3.07±0.99
Length of service (yrs)			
<5	325 (80.6)	3.52±0.77 ^a	3.91±0.72 ^a
5–10	71 (17.6)	2.79±0.68 ^b	3.09±0.87 ^b
>10	7 (1.7)	2.03±0.92 ^c	2.86±0.83 ^c
Smoking habits			
Non-smokers	332 (82.4)	3.68±1.02 ^a	3.89±0.99 ^a
Smokers	71 (17.6)	3.37±0.81 ^b	3.56±1.02 ^b

Mean values with different superscripts are significantly different.

of occupation is a matter of public health concern both to the women and their unborn babies.

A high prevalence of respiratory problems was noted in this study; the most common problems were occasional chest pain (47.6%), occasional cough (40.7%)—the least problem was sputum mixed with blood (0.5%). These results are comparable with results of previous studies in Iran¹⁶ and Rio de Janeiro, Brazil¹⁷. The study in Iran¹⁶ reported irritative cough in 75% of the respondents, while that in Rio de Janeiro¹⁷ reported cough in 31.9% with expectoration in 41.7%. It therefore, seems reasonable to associate the respi-

ratory problems recorded in the present study with the respirable quarry dust; a similar study reported association between chronic exposure to dust generated from crushing of granite rocks with impaired lung function and some respiratory and non-respiratory symptoms.⁸

Data on the availability of medical care in the quarry industrial site and use of protective device by the quarry workers indicated that there was a total absence of medical care in the study area and a near absence of protective device usage by the workers. This may, in part, account for the high prevalence of some of the respiratory problems reported in this study, which in

Table 4: Radiological findings of quarry workers at Umuoghara stone quarrying industrial site, Abakaliki, Nigeria

Radiological appearance	Frequency (%)
Normal	272 (67.5)
COAD*	68 (16.9)
Bacteria pneumonitis	35 (8.7)
Pulmonary tuberculosis	13 (3.2)
Cardiomegaly	15 (3.7)
Total	403 (100)

*Chronic obstructive airway disease

turn accounts for a decline in the mean FEV_1 and FVC values of the respondents. Only 13.7% of the dust-exposed workers had their mean FEV_1 values in the green zone of 4.00–6.50 L (data not shown), indicating that the lung function of majority of the respondents had been impaired. Although the mechanism by which dust particles reduce lung function is obscure, it may be that inhaled dust particles are lodged in the lung causing irritation and inflammatory reactions. It has been found that healing of this inflammatory process would cause fibrosis leading to defective oxygen diffusion and impaired pulmonary function.⁷

The significant decline in the mean FEV_1 and FVC values and the negative correlation between duration of work and FEV_1 ($r = 0.198$, $p < 0.05$) showed that the longer the respondent was exposed at work, the lower the values. These results are in corroboration with results of previous studies, which have attributed decreased FEV_1 and FVC to loss of lung function.^{2,17–20} Although FEV_1 declined with age in the present study, it had no significant correlation with age ($r = 0.079$). Previously, reduction in lung function has been reported in cotton workers, coal miners, grain and flour mill workers, workers exposed to tobacco dust, barley dust, talc

dust and in quarry workers.²¹

The significant reduction in lung functions among smokers observed in the present study is in corroboration with the findings of a previous study.¹⁸ It however contrasted the findings of Ghotkar, *et al*,¹¹ in which no significant difference was observed between mean values of pulmonary function indices of non-smoker and smoker male workers. Results of previous studies have also concurred that decline in lung function values is significantly higher among individuals with both silica and tobacco exposure than in those with either one, *per se*.^{22,23}

It is interesting to note that in addition to respiratory diseases observed among the subjects, a reasonable proportion (3.7%) of participants had hepatomegaly. This suggests that heart disease (hypertension) may be prevalent among the quarry workers. Although we did not include measurement of blood pressure in the original design of the present study and there is paucity of data on the relationship between exposure to dust and incidence of hypertension, there is need to explore this possibility in future studies.

Data from the present study suggest that chronic exposure to dust from crushing of rocks may increase susceptibility to respiratory problems and impaired lung function with tobacco or cigarette smoking and increased length of service as additional predisposing risk factors. Suggested mitigating measures include provision of safety measures (*e.g.*, face masks, apron, hand gloves), discouraging workers from tobacco/cigarette smoking through public health education, frequent assessment of lung functions and redeployment of workers with severely reduced lung functions to other less hazardous occupations, and above all, provision of legislative instrument by the Federal government making establishment of quarry without adequate provision of

necessary safety measures a punishable offence.

Conflicts of Interest: None declared.

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