Occurrence of respiratory and skin problems among manual stone-quarrying workers

O C Ugbogu, J Ohakwe, and V Foltescu

Abstract

An evaluation of dust-related problems associated with manual stone quarrying at Lokpa in Umuchieze, a rural community in Umunneochi Local Government Area of Abia State, Nigeria was carried out. The major objectives were to ascertain the nature of the parent rock material from which the quarry workers inhale dust, and to establish if there is a positive relationship between the manual stone quarrying and occurrence of symptoms of respiratory disease symptoms and skin dermatoses. The elemental analysis and silica content of parent rock materials and dust samples were carried out at three quarry sites designated A,B, and C. Questionnaires were administered to 270 quarry workers and a control population of 290 non-quarry workers. The smokers and asthmatics were removed leaving a sample size of 202 quarry workers and 220 non-quarry workers. The questionnaires were used to ascertain the relationship between manual stone quarrying and dust inhalation and the occurrence of respiratory disease symptoms and dermatoses. The knowledge of the manual quarry workers about the health implications of their work was also assessed. Elemental analyses showed that the rock and the resulting dust particles contained iron, zinc, cadmium, nickel, lead, chromium, barium, beryllium, and aluminium. Exposure to these metals and silica are known to cause pneumoconiosis. The test of proportion ($p \geq 0.05$) shows that there is an association between dust inhalation and the occurrence of respiratory disease symptoms and skin dermatoses. About 83% of quarry workers know that their work exposes them to health hazards but cannot quit owing to poverty or lack of social welfare etc. This study is indicative and can be extrapolated to pockets of other stone-quarrying communities in Nigeria. There is a need for further studies of occupational exposure to dust, especially in developing countries.

O C Ugbogu and J Ohakwe, Department of Microbiology, Abia State University, Uturu, Abia State, Nigeria; and V Foltescu, Swedish Meterological and Hydrological Institute, Norrkoping, Sweden. Correspondence to: Ositadinma Chinyere Ugbogu, Department of Microbiology, Abia State University, PMB 2000, Uturu, Abia State, Nigeria. Email: osychin@yahoo.com

Introduction

In many industrial processes, mineralogical materials are introduced into the environment as dust, fumes, ashes, or other industrial waste. Some of the elements so released into the environment may be toxic and constitute a health risk to humans and animals alike.[1] In Nigeria, the greatest pollution effects come from exploitation of petroleum, limestone, and rocks used in construction work.[2] Large volumes of dust from cement factories and mining operations in the Nigerian quarries are discharged daily into the air. A lot of airborne particulate matter is generated by the numerous stone-crushing industries. In general, greater damage and the worst effects are witnessed in localities where tribute workers mine the minerals manually.[3]

Dust particles are small dry particles ranging in size from 1 to 100 µm in diameter. They may be airborne depending on their origin, physical characteristics, and ambient conditions. Whenever dust particles are deposited either on the head or in lungs they have the potential to cause harm either locally or subsequently elsewhere in the body.[4] A study in India reported the prevalence of silicosis among workers engaged in quarrying shale sedimentary rock. The report stated that adults last about 14 years in this trade and are often replaced by their children who themselves become severely ill within 5 years.[5]

Hazardous dusts in the work environment include mineral dusts in the environment, mineral dusts from extraction and processing of minerals, metallic dusts (containing lead, cadmium, and their compounds among others), other chemical dusts such as bulk chemicals and pesticides, vegetable dusts (such as wood, flour, cotton), and moulds and spores.

Workers in developing countries are often exposed to dust though they may not be aware of its dangers.[6] Most studies, especially from developed countries, have focused on the health effects of airborne particulate matter (PM) <10 µm in diameter (PM_{10}) or particles <2.5 µm in diameter ($PM_{2.5}$). In the main, cohort studies relating hospital admissions and respiratory cardiovascular disease to particulate matter are used.[7-9] In developing countries, where poverty and unemployment are major problems (coupled with the unavailability of efficient welfare services), hospital admission statistics are not adequate for cohort studies, especially in establishing the effect of particulate matter on health.

Occupational exposure to dust is a widely known phenomenon especially in developing countries,[3,6] despite

the fact that the adverse effects of ambient air pollution and particulate matter have been well established.[10] Coarse airborne particles have been shown to have an adverse effect on health.[11,12] Particles that remain in the body for a long time increase the potential to cause disease. This is why inhaled particles are important in relation to environmental evaluation and control. During mineral extraction, work on limestone presents a minor health hazard, but work on hard rocks such as granite, grit-stones, or sandstones may expose workers to very dangerous levels of respiratory dust with high content of free crystalline silica. It has been shown that the accumulation of large enough burdens of insoluble particles in the lungs leads to impaired clearance. This so-called 'dust overload' condition may occur as a result of prolonged occupational exposures, even at relatively low levels.[4]

Research has shown that an excess of laryngeal cancer occurred for workers potentially exposed to silica dust,[13] which is a well known cause of silicosis.[14,15] Exposure to dust is also known to cause various types of dermatoses.[4] This work reports on the relationship between manual stone quarrying and the occurrence of respiratory disease symptoms among the quarry workers, the prevalence of dermatoses on the quarry workers compared to a control population, and the level of knowledge of the workers on the impact of dust inhalation to their health.

Materials and methods

The quarry area studied is located in Lokpanta in Umuchieze community, Umunneochi Local Government area, Abia State. Rock particles and dust particles were collected from three sites at the quarry area. The rock particles and dust fallouts were taken to the International Energy Services Ltd laboratory in Port Harcourt, Nigeria for elemental analysis and determination of silica content. The levels of selenium, iron, zinc, cadmium, nickel, lead, chromium, beryllium, and aluminium were analysed using atomic absorption spectroscopy (AAS). The UNICAM 969 atomic absorption spectrophotometer was used to determine the concentration of each element after successful digestion of the samples.

Survey of the occurrence of respiratory symptoms among stone-quarry workers

Questionnaires were administered to 202 quarry workers and a control population of 220 non-quarry workers (smokers and those who responded affirmatively to the question 'Have you been treated by a physician or in a hospital for asthma?' were not included in the survey). Demographic data of respondents were collected to ascertain the occurrence of respiratory symptoms. The wording of the questions used in the analyses included the following:

- Do you usually cough or clear your throat in the morning?
- Do you have a cough for 3 months or more in total during a year?
- Do you have phlegm when coughing?
- Are you breathless when you walk and ascend a hill at an ordinary pace?
- Do you wheeze in your chest?

The pre-printed alternatives for answers were 'yes' and 'no'.

Survey of the occurrence of skin dermatoses

The questions used for this study were:

- Do you have any skin infection?
- Have you noticed any skin infection/rash you feel is related to your work?

The alternative answers were 'yes' and 'no'.

Survey of the knowledge of the quarry workers about the impact of manual stone quarrying to their health and precautions taken by them

The data for this study were collected through questionnaires. The respondents are expected to answer 'yes' or 'no' to the questions:

- Do you know that exposure to dust in the quarry environment can affect your health negatively?

The questions used to ascertain the level of precautions taken by the quarry workers were:

- Do you wear protective goggles for your eyes?
- Do you cover your nostrils from dust while quarrying or sieving stones?
- Do you wear overalls during your work hours?

Data analysis

The elemental composition and silica content of the rock particles and dust samples were presented as means of triplicate determinations. The test of proportion which is a comparison of the proportions of the subjects with those of the population ($p \geq 0.05$) was used to determine the association of respiratory disease symptoms and skin diseases with quarrying. A Z value higher than the theoretical value shows a higher incidence of respiratory disease symptoms and dermatoses among the quarry workers.

Results

The elemental composition of the rock particles is presented in Table 1. The demographic characteristics of the study population is presented in Table 2. The test of proportion ($p > 0.05$) shows there is an association between dust inhalation and the occurrence of respiratory disease symptoms. There is also an association between the occurrence of skin dermatoses and dust exposure at the same level of significance (see Table 3).

The majority of the quarry workers knew that their job exposed them to health hazards. About 87% of the responders acknowledged that their working environment could negatively impact on their health. About 83% of the respondents would prefer other jobs to quarrying, and only 6% covered their nostrils during work (see Table 4).

Table 1 Silica and heavy metal levels in stone and dust samples (mg/kg)

	Site A		Site B		Site C	
Element	**Stone**	**Dust**	**Stone**	**Dust**	**Stone**	**Dust**
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	12.50	11.30	2087.00	2005.00	5505.00	4856.00
Zinc	1.86	1.56	3.41	3.40	44.80	41.20
Cadmium	1.54	1.42	1.47	1.38	1.61	1.52
Nickel	0.01	<0.01	0.98	0.76	1.64	1.62
Lead	<0.01	<0.01	1.74	1.69	<0.01	<0.01
Chromium	2.16	2.11	5.56	5.46	8.15	8.02
Barium	12.20	12.00	16.80	16.60	19.60	18.10
Beryllium	0.14	0.11	0.08	0.06	0.21	0.20
Aluminium	4.01	4.00	295.00	293.00	2756.0	2400.00

Table 2 Demographic characteristics of study population

Characteristics (n=422)	
Sex	69.9% male
Quarry workers	71.8% male
Non quarry workers	68.2% male
Marital status	48.8% married
Quarry workers (% married)	47.5% married
Non quarry workers (% married)	50.0% married
Age range	**% distribution**
7–16 years	21.1
17–26 years	29.1
27–26 years	21.1
37–46 years	14.7
47–56 years	13.7

Table 3 Relationship between quarrying and occurrence of respiratory disease symptoms and dermatoses

	Quarry workers (n=202)	Non-quarry workers (n=220)	Pooled proportion	Zcal	Ztab 5%
Respiratory symptoms	172 (0.85)	86 (0.39)	0.61	9.68	±1.96
Skin infection	156 (0.77)	74 (0.34)	0.55	8.50	

Note
Numbers in brackets are proportions (p≥0.05)
Zcal=calculated value, Ztab=tabulated value

Table 4 Knowledge of quarry workers regarding the impact on their health and use of protective clothing

Characteristic	**Yes (%)**	**No**
Knowledge of effect on health	167 (82)	35 (18)
Wearing of overalls	25 (12)	177 (88)
Covering of nostrils	12 (6)	190 (94)
Eye goggles	0 (0)	202 (100)

Discussion

The health risks associated with exposure to the dust largely depend on the type and composition of dust. Physical, chemical, and mineralogical characteristics of the dust will determine its toxicological properties and hence the resulting health effects. The analyses of the elemental composition of the rock and dust samples show that both the rock and dust contain high levels of some heavy metals.

Unlike other pollutants that may visibly build up in the environment, trace metals may accumulate unnoticed to toxic levels. Sites A and C contain less than 0 .01 mg/kg of lead (Pb) but stone and dust particles from site B contain lead concentrations of 1.74 and 1.69 mg/kg, respectively. Although lead is ubiquitous in the environment, as a pollutant it is essentially of anthropogenic origin.[16] The toxicity of lead is well known and lead has been described as the most severe environmental contaminant to arise in human civilisation.[17,18]

Obviously manual quarry workers at site B are exposed to higher concentrations of lead than in the other two sites studied. These manual quarry workers are also exposed to other heavy metals, namely iron, cadmium, chromium, barium, beryllium, and aluminium. Inhalation of excessive amounts of dust causes pneumoconioses; beryllium causes berylliosis while barium causes siderosis. All these conditions except berylliosis are relatively benign. The exposure of these manual quarry workers is worrying, especially as they operate in rural areas and do not have access to modern healthcare facilities. High exposure to cadmium may cause kidney damage. Severe cadmium poisoning causes osteoporosis.[19–21]

The stone-quarry manual workers are exposed to dust from the rocks they crush, especially during sieving of the crushed rock materials, as they do not wear protective equipment. A comparison of the occurrence of respiratory disease symptoms between manual quarry workers and a control population shows that there is a higher occurrence of respiratory diseases symptom among the quarry workers. Dusts are known to affect health.[4] Epidemiological evidence of the effects of coarse airborne particles on health exists in the scientific literature.[11,22–24] Dusts also have adverse health effects on organs other than the lungs. Several studies showed effects such as cardiovascular diseases related to dust exposure.[25] There is a possible association between occupational exposure to dust and ischaemic heart disease.[26] Since the manual quarry workers depend on quarrying for their livelihood, prolonged exposure to dust is the mostly likely scenario. The quarry workers do not use any protective equipment for their eyes, only 5.9% attempt covering their nostrils, while only 12.3% use overalls. The exposure of these people to dust is of concern.

There was also a higher occurrence of dermatoses among the quarry workers than in the control population. Exposure to dust is known to cause dermatoses.[4]

The impact of the occupational exposure to dust on the health of the manual quarry workers is of concern, especially as most of them are aware of the impact on their health and yet cannot leave the industry. The major problems are the poverty and lack of social welfare in developing countries. It is also important to note that in most of Nigeria the population is subject to occasional exposure to dust, especially during the dry season, since most of the roads in rural areas are not tarred and are usually dusty. The provision of basic infrastructure to the quarry community, and the establishment of co-operative societies that will involve mechanisation of the quarry, would go along way in reducing the risk associated with manual stone quarrying.

Developing countries such as Nigeria are managing to reduce air pollution and have not performed studies that correlate hospital admissions to airborne particles, since most of the population does not have access to healthcare. There is a need for further studies, especially those involving a large population and other manual quarrying communities in Nigeria.

Conclusion

This study shows that occupational exposure to dust is still a major cause for concern in developing countries, especially in Nigeria where manual stone quarrying is a means of earning a living, especially for people in rural areas. This study at Lokpa is just the tip of the iceberg and is indicative of what is obtainable in other manual quarrying communities in Nigeria. There is a need for public health enlightenment of the workers in the manual stone quarries across the country. More importantly the government should establish legislation on illegal mining of rocks and provide a means of earning a living for the people who work in stone quarrying.

References

1. Obiajunwa EI, Nwachukwu JI. Elemental analysis of limestone samples from Ewekoro limestone deposit in south-western Nigeria. *Nucl Instrum Methods Phys Res Sect B* 2000; 170: 427–31.
2. Proceedings of the UNESCO-MAB regional training workshop, Akure, Nigeria, 23–26 July 1995; pp 314–23.
3. Aigbedion I, Iyayi SE. Environmental effect of mineral exploitation in Nigeria. *Int J Phys Sci* 2007; 2: 33–8.
4. World Health Organization. Prevention and control exchange: Hazard prevention and control in the work environment. Geneva: WHO, 1999; pp 219.
5. Durvasula R. *Occupational health information systems in developing countries – India*: A case study presented at the IV Takemi Symposium on International Health in the Third World: Problems and Policies, 29 September–1 October 1990. Boston: Harvard School of Public Health.
6. Fatusi A, Erbabor G. Occupational health status of sawmill workers in Nigeria. *J Roy Soc Health* 1996: 116: 232–6.
7. Anderson HR, Bremner SA, Atkinson RW, Harrison RM, Walters SC. Particulate matter and daily mortality and hospital admissions in the west midlands conurbation of the United Kingdom: association with fine and coarse particles, black smoke and sulphate. *Occup Environ Med* 2001; 58: 504–10.
8. Burnett RT, Cakmak S, Brook JR, Krewski D. The role of particulate size and chemistry in the association between summertime ambient air pollution and hospitalization for cardiorespiratory diseases. *Environ Health Perspect* 1997; 105: 614–20.
9. Moolgavkar SH. Air pollution and hospital admissions for disease of the circulatory systems in three US metropolitan areas. *J Air Waste Manage Assoc* 2000; 50: 1199–1206.
10. Bakke PS, Hanva R, Gulsvik A. Relation of occupational exposure to respiratory symptoms and asthma in a general population samples: self reported versus interview-based exposure data. *Am J Epidemiol* 2001; 154: 477–83.
11. Brunekreef B, Forsberg B. Epidemiological evidence of effects of coarse airborne particles on health. *Eur Respir J* 2005; 26: 309–18.
12. Sandstrom T, Nowak D, Van Bree L. Health effects of coarse particles in ambient air: messages for research and decision-making. *Eur Respir J* 2005; 26: 187–8.
13. Elci OC, Akpinar EM, Blair A, Dosemeci M. Occupational dust exposure and the risk of laryngeal cancer in Turkey. *Scand J Work Environ Health* 2002; 28: 278–84.
14. Lippman, M. Exposure assessment strategies for crystalline silica health effects. *Appl Occ Environ Hyg* 1995; 10: 981–90.
15. Golbabaei F, Barghi MA, Sakhaei M. Evaluation of workers' exposure to total, respirable and silica dust and the related health symptoms in Senjedak stone quarry, Iran. *Indust Health* 2004; 42: 29–33.
16. Onianwa PC, Fakayode SO. Lead accumulation of top soil and vegetation in the vicinity of a battery factory in Nigeria. *Environ Geochem Health* 2000; 22: 211–18.
17. Smith DR, Flegal AR. Lead in the Biosphere, recent trends. *Ambio* 1995; 24: 21–3.
18. Nnorom IC, Osibanjo O. Determination of lead and cadmium content of dry cell batteries available in Nigeria. *J Appl Sci Environ Manag* 2002; 10: 37–41.
19. Olsson IM, Ericksson J, Oborn I, Skerfving S, Oskarsson A. Cadmium in food production systems: A health risk for sensitive populations. *Ambio* 2005; 34: 344–51.
20. Jarup L, Berglund M, Elinder CG, Nordberg G, Vahter M. Health effect of cadmium exposure – a review of the literature and a risk estimate. *Scand J Work Environ Health* 1998; 24: 1–51.
21. Jin T, Nordberg YT, Bo, M, et al. Osteoporosis and renal dysfunction in a general population exposed to cadmium in China. *Environ Res* 2004; 98: 215–23.
22. Wilson WE, Su HH. Fine particles and coarse particles: concentration relationships relevant to epidemiologic studies. *J Air Waste Manage Assoc* 1997; 47: 1238–49.
23. Clairborne CS, Finn D, Larson TV, Koenig JQ. Windblown dust-contributes to high PM 2.5 concentrations. *J Air Waste Manage Assoc* 2000; 50: 1440–5.
24. Schwartz J. Air pollution and hospital admissions for respiratory disease. *Epidemiology* 1996; 7: 20–8.
25. Seaton A, MacNee W, Donaldson K , Godden D. Particulate air pollution and acute health effects. *Lancet* 1995; 345: 176–8.
26. Sjogren B. Occupational exposure to dust. Inflammation and ischaemic heart disease. *Occup Environ Med* 1997; 54: 466–9.