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Original Research Article

Exposure to respirable dust and factors associated with abnormal pulmonary function among stone diggers in Kayole quarries, Nairobi City County, Kenya

Fredah Wanjiku Mwangi*, Peterson Warutere, Anthony W. Nyambura

Department of Environmental and Occupational Health, Kenyatta University, Nairobi, Kenya

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***Correspondence:**
Fredah Wanjiku Mwangi,
E-mail: datafastconsultants@gmail.com

ABSTRACT

Background: In Kenya, the quarry industry suffers several constraints: some quarry workers get injured, others get chronic diseases, while some die. This study assessed occupational exposure to respirable dust and factors associated with abnormal pulmonary function among quarry stone diggers in Mihang'o and Matopeni quarries in Kayole Nairobi City County, Kenya.
Methods: The study was done in Mihang'o and Matopeni quarries. An analytical cross-sectional design was used and a sample size of 165 respondents was taken. An interviewer administered semi structured questionnaire. Spirometry tests were done by a qualified technician to assess pulmonary function. Respirable dust levels were determined with the aid of a particle counter. Descriptive statistics like frequency, means were used to summarize data and results were presented in frequency tables and graphs. Chi square tests and logistic regression were done. T tests were done to compare the means of dust levels in the two quarries.
Results: This study found the daily mean levels of PM2.5 and PM10 were higher than the levels recommended by WHO. The age of the respondents, presence of respiratory symptoms, years of work experience, nostril covering, and smoking were factors associated with abnormal pulmonary function at ($p \leq 0.05$).
Conclusions: In conclusion, chronic exposure to quarry dust increases the risk of developing respiratory symptoms and abnormal pulmonary function. This study recommended that routine particulate matter monitoring should be done in Nairobi quarries to provide data that can inform decisions on air pollution control actions.

Keywords: Occupational exposure, Respirable dust, Abnormal pulmonary function, Quarry stone diggers

INTRODUCTION

Quarry workers are exposed to several respiratory hazards arising from breathing quarry airborne particles and these causes a significant risk to their respiratory health. Exposure to silica dust in some quarries is a special concern because silica dust causes silicosis which is an irreversible respiratory disease that causes breathing problems to progress even after exposure ceases.[1] There is a clear connection between exposure to silica dust and risk of chronic respiratory diseases among exposed quarry workers.[2] Globally, incidences of pneumoconiosis were reported at 453,000 and other respiratory illnesses resulting from occupational exposure were estimated at 2,631,000 cases per year.[3] In China, there was a positive association between exposure to respirable silica and high mortality from silicosis lung cancer, respiratory tuberculosis and cardiovascular diseases among mine workers.[4] In Britain, work related respiratory diseases had an annual prevalence of 44 per 1000 among workers in dusty occupations, specifically mining and quarrying occupations were associated with 20% of the actual

reported cases of silicosis.[5] In Germany, those who worked as quarrymen had an increased risk for all subtypes of lung cancer and notably, ore miners showed high Odds Ratio of 3.36 for developing adenocarcinoma.[6]

Gholami et al showed a prevalence of respiratory symptoms ranging from 11.5% to 21.3%.[7] Symptoms of cough were reported at 20.7%, phlegm at 11.5%, wheezing at 11.5% and shortness of breath at 21.3% and significant p values for developing a cough, a wheeze and dyspnea. This study also reported that factors associated with abnormal pulmonary function were smoking, years of work experience and the presence of respiratory symptoms. While in Bangladesh, Kabir et al reported that the use of dust PPE, smoking and age were correlated with abnormal pulmonary function among stone crushing workers.[7] Research done in Africa also shows prevalence rates of respiratory symptoms to be high amongst workers involved in dusty occupations. In Edo state Nigeria, the prevalence of chest tightness amongst Quarry workers was (35.5%), cough occurred at (23.7%), phlegm at (21.1%), dyspnea at (7.9%), wheezing at (10.8%) and nasal congestion at (27.0%).

Smoking was significantly associated with abnormal pulmonary function. In Ethiopia's Dejen cement factory, chronic respiratory symptoms were prevalent among 62.9% of the workers where persistent cough was reported at 24.5%, chronic wheezing at 36.9%, chronic phlegm at 24.5%, chronic chest pain at 21. % and chronic breathlessness at 38.6%.[7] In Nyamira county Kenya, Ruth et al reported that cases of cancers, respiratory illnesses, skin and eye ailments, in quarry workers and nearby members of the community accounted for 21-23% of the disease burden in Nyamira County Hospital.[8]

According to the Nairobi County Integrated Development plan of 2017, there is a considerable number of about 7,846 people working directly in the Nairobi quarries and an estimated 500 work in Kayole quarries.[8] In Nairobi small scale quarries like those of Kayole there is scarce information on the impacts of dust exposure on quarry workers' respiratory health as the available studies were done in other parts of Kenya, Meru (Mutonga), Kajiado and did not specifically focus on exposure to respirable dust and resultant respiratory outcomes.[9,10] As such, it is important to understand respiratory risks associated with quarry airborne particulate matters hence the need for a study occupational exposure to respirable dust and factors associated with abnormal pulmonary function among stone diggers in Mihang'o and Matopeni quarries in Kayole Nairobi City County, Kenya.

METHODS

An analytical cross- sectional design was used because the study was done at one point in time and involved identifying and determining whether an association exists between exposure to quarry dust and the presence of respiratory impairments. The independent variables in the study were respirable dust, demographic factors like sex, age, and Marital Status and socioeconomic factors such as education levels of the respondents. The intervening variables were dust concentration and exposure duration. While the dependent was pulmonary function. The study population was all quarry workers in Mihang'o and Matopeni quarries in Kayole. While the target population was quarry stone diggers who were 18 years or above working in Mihang'o and Matopeni quarries that were estimated to be 475 in total. A minimum sample of 165 participants was selected using simple random sampling.

The inclusion criteria consisted of only quarry stone diggers who are over 18 years and with over 6-month experience on the job and who consented were included and allowed to take part in this study. Quarry stone diggers who are mentally unstable were excluded. All quarry stone diggers who had previously been diagnosed with heart disease, arrythmia or who had a recent surgery were also excluded in accordance with pulmonary function test exclusion criteria for spirometry test.[11]

After data collection, the questionnaire was coded and entered in Statistical Package for Social Sciences (SPSS) Version 25 for analysis. Descriptive statistics like frequency, mean, standard deviations and percentages were used in summarizing the data and results were presented in frequency tables and graphs. Chi square tests and logistic regression were done to determine associations between different study variables. Odds ratios were also computed at 95% confidence level using two by two contingency tables, t tests were also done to compare means of study variables in two groups. The study took a period of 6 months (March 2022 to November 2022).

RESULTS

Socio-demographic characteristics of the respondent

A total of 165 respondents participated in this study and demographic variables assessed were: sex, age, weight, height, education level, marital status (Table 1). Majority 82.4% (136) of the respondents were male and 17.6% (29) were female, the mean age of the respondents was 34.70±8.5 years with the youngest respondent being 20 years and the oldest being 56 years. The average weight was 65.17±7.5 kg with the lowest weight being 55.0 kg and the highest being 92.5 kg. The mean height of the respondents was 166.4±5.9 cm with the lowest height being 153.5 cm and the highest being 177.5 cm. The average BMI was 23.49±1.9 and about 7.8% of the respondents were slightly overweight.

Majority 52.7% (87) of the respondents had primary level education, 39.4% (65) had secondary level education, 4.8% (8) had tertiary education and 3.0% (5) did not have formal education. Most 63.6% (105) of the respondents were married, 26.7% (44) were single, 7.9% (13) were separated or divorced and 1.8% (3) were windowed.

Table 1: Distribution of stone diggers in Mihango and Matopeni quarries by socio demographic characteristics.

Demographic variables		N	%
Gender	Male	136	82.4
	Female	29	17.6
Age (years)	18-27	39	23.6
	28-37	70	42.4
	38-47	37	22.4
	48-57	19	11.5
Weight (kg)	55.0-64.9	94	56.9
	65.0-74.9	58	35.1
	75.0-84.9	8	4.8
	85.0-94.9	5	3.0
Height (cm)	153.0-162.9	51	30.9
	163.0-172.9	89	53.9
	173.0-176.0	25	15.2
Education Level	No formal education	5	3.0
	Primary	87	52.7
	Secondary	65	39.4
	Tertiary	8	4.8
Marital Status	Single	44	26.7
	Married	105	63.6
	Separated/ Divorced	13	7.9
	windowed	3	1.8

Bivariate analysis

The presence of respiratory symptoms was significantly associated with abnormal pulmonary function at (p=0.0001) and respondents with respiratory symptoms had a higher likelihood of having lower pulmonary function values and the odds ratio was 5.9. There was a significant association between years of work experience and abnormal pulmonary function at (p=0.001) and respondents with 6 or more years of work experience had a higher likelihood of having abnormal pulmonary functions and the odds ratio was 4.5.

However, the number of days worked per week and hours worked per day were not significantly associated with abnormal pulmonary functions at (p≥0.05). Covering of nostrils when working in the quarry was significantly associated with abnormal pulmonary functions at (p=0.02) and respondents who did not cover their nostrils while working in the quarry were almost three times more likely to have abnormal pulmonary functions and the odds ratio was 2.9. The item or materials used to cover the nostril was also significantly associated with abnormal pulmonary functions at (p=0.01), respondents who covered their nose using unrecommended items such as handkerchief, headscarf were 3.4 times more likely to have abnormal pulmonary function. The number of times gone to hospital was significantly associated with abnormal pulmonary function at (p=0.0001). Respondents with abnormal pulmonary function had a higher likelihood of going to hospital compared with those that had normal pulmonary function values and the odds ratio was 5.3. Smoking habits of the respondents were significantly associated with abnormal pulmonary function at (p=0.0001).

Respondents who were smokers were more likely to have abnormal pulmonary functions compared with non-smokers and the odds ratios were notably high at 38. The quarry of work was not significantly associated with abnormal pulmonary function at (p=0.96). The gender of the respondents was not significantly associated with abnormal pulmonary function at (p=0.88). The age of the respondents was significantly associated with abnormal pulmonary function at (p=0.002). Older respondents who were 35 years of age and above had a higher likelihood (odds ratio=6.3) of having abnormal pulmonary functions compared with those who were less than 35 years of age. BMI, level of education and marital status were not significantly associated with abnormal pulmonary function at (p≥0.05).

Multivariate analysis

At multivariate analysis, the presence of respiratory symptoms was significantly associated with abnormal pulmonary function at (p=0.03) and respondents with respiratory symptoms were five times more likely to have abnormal pulmonary function values when compared to those without the symptoms (AOR=5.3 at 95% CI=1.14-23.31). Smoking was significantly associated with abnormal pulmonary function at (p=0.001) and respondents who were smokers were more likely to have abnormal pulmonary function when compared with nonsmokers (AOR=50 at 95% CI=10.0-250.0). The age of the respondents was also significantly associated with abnormal pulmonary functions at (p=0.02) and older workers with 35 years and above were five times more likely to have abnormal pulmonary function values when compared to younger workers who were 34 years and below (AOR=5.1 at 95% CI=1.33-19.23). All the other factors (years of work experience, covering of the nostril, item/ material used to cover and going to hospital) were not significantly associated (p≥0.05) with abnormal pulmonary function at multivariate (Table 3).

DISCUSSION

The levels of respirable dust in Mihang'o and Matopeni quarries in Kayole were way higher than the levels of 25µg/m^3 and 50µg/m^3 for $PM_{2.5}$ and PM_{10} respectively recommended by WHO. This finding is consistent with a study done in Jammain Palestine by Sayara et al where the ambient $PM_{2.5}$ level was reported to be 61.5 ug/m^3 and 79.2 ug/m^3 at 2 locations 200 m and 100 m away respectively from quarry operation site.[12]

Table 2: Factors associated with abnormal pulmonary function among stone diggers in Mihango and Matopeni quarries.

Variable	Category	Pulmonary Functions					
		Abnormal	Normal	Chi-Square	Odds Ratio (OR)	Confidence Interval	
						Lower	Upper
Presence of Respiratory symptoms	No	18	107	χ^2=21.67, df=1, p=0.0001	OR=5.9	2.68	13.16
	yes	20	20				
Duration of work experience in years	5 years or less	6	58	χ^2=10.99, df=1, p=0.001	OR=4.5	1.75	11.49
	6 or more years	32	69				
Days worked per week	3 to 5 days	8	18	χ^2=1.04, df=1, p=0.31	OR =0.6	0.25	1.56
	Over 5 days	30	109				
Hours worked per day	6 to 8 hours	34	121	χ^2=1.73, df=1, p=0.19	OR =2.4	0.63	8.92
	Over 8 hours	4	6				
Covering of Nostril	Covered	7	50	χ^2=5.68, df=1, p=0.02	OR =2.9	1.18	7.03
	Did Not cover	31	77				
Item/Material used to cover	mask	5	43	χ^2=6.08, df=1, p=0.01	OR =3.4	1.23	9.26
	Other unrecommended items	33	84				
Either gone to hospital or not	Had gone to hospital	11	9	χ^2=13.12, df=1, p=0.0001	OR=5.3	2.02	14.16
	Had not gone to hospital	27	118				
Smoking Status	Never Smoked	17	123	χ^2=61.79, df=1, p=0.0001	OR=38	11.63	125
	Had ever smoked	21	4				
Quarry of work	Mihango	16	54	χ^2=0.002, df=1, p=0.96	OR=1.0	0.49	2.11
	Matopeni	22	73				
Gender	Male	31	105	χ^2=0.02 df=1 p=0.88	OR=0.9	0.36	2.38
	Female	7	22				
Age	Young workers (20-34) years	5	62	χ^2=10.08, df=1, p=0.002	OR=6.3	2.31	17.24
	Older workers (35-56) years	33	65				
Bmi	Normal	34	118	χ^2=0.48, df=1, p=0.49	OR=1.5	0.45	5.32
	Overweight	4	9				
Education Levels	Low level	26	66	χ^2=3.21, df=1, p=0.73	OR=2.0	0.93	4.31
	High level	12	61				
Marital Status	Single	10	50	χ^2=2.15, df=1, p=0.14	OR=0.6	0.25	1.23
	Married	28	77				

However, this finding is in contrast with a study done in Chilanga Zambia where the level of $PM_{2.5}$ ranged from 2.39-24.93 µg/m^3 in different seasons.[12] This variation in $PM_{2.5}$ levels is due to changes in season and direction of the wind that affect the ambient concentration of particulate matter.

Table 3: Binary logistic regression between variables and abnormal pulmonary function.

Variables	Abnormal pulmonary function			
	P value	Ratio Adjusted Odds	Confidence Interval at 95%	
			Lower	Upper
Presence of respiratory symptoms	0.03	5.2	1.14	23.31
Work experience in years	0.13	2.9	0.73	11.90
Covering of Nostril	0.19	3.4	0.55	20.41
Item/Material Used to cover	0.07	6.1	0.84	43.47
Either gone to hospital or not	0.06	5.6	0.93	33.43
Smoking	0.001	50	10.00	250.0
Age	0.02	5.1	1.33	19.23

Chronic exposure to quarry dust increases the risk of developing respiratory symptoms and the prevalence of these symptoms among stone diggers in Mihango and Matopeni quarries was 24.2%. These symptoms were persistent cough, throat clearing, chest pain and tightness, persistent cold, shortness of breath and wheezing. These findings agree with a study done by Isara et al in Nigeria where Chest pain and tightness were reported at 35.5%, cough at 23.7%, sputum at 21.1%, dyspnea at 7.9% and wheezing at 10.8% among the exposed group. This finding is further affirmed by Kabir et al who reported cough at 28.3%, shortness of breath at 4.6%, wheeze at 2.3% and chest tightness at 1.68% among quarry stone crushers.

Prolonged exposure to quarry dust lower lung function and pulmonary capacities of quarry workers. 23% of the quarry workers had lower pulmonary function than the recommended value of 80% indicating the presence of both restrictive (12.7%) and obstructive (10.3%) lung diseases. This finding is inconsistent with a study done among stone crushers in Lalmonirhat Bangladesh where only 6.7% had obstructive pulmonary disorders and only 2.5% had restrictive pulmonary disorders. The reason is because in the Bangladesh study Kabir et al reported that majority (95.3%) of the respondents had a work experience of $\leq$5 years but in this study over 80% of the respondents had over 5 years of work experience hence higher prevalence of respiratory disorders because of longer exposure durations. Factors associated with abnormal pulmonary function were the presence of respiratory symptoms, years of work experience, usage of dust PPEs, having gone to hospital, smoking habits and age of the respondents. In particular, the presence of respiratory symptoms, smoking habits and age of the respondents were key predictor factors for reduced pulmonary function. This finding concurs with a study done by Gholami et al where the mean years of work experience among quarry workers in Eastern Iran was 8.0$\pm$3.3. This finding was further affirmed by Sahbanathul et al in a study done in India where 16.6% of the quarry workers were reported to have work experience of 1 to 5 years, 25% had 6 to 10 years, 35% had 11 to 15 years and 23.3% had over 15 to 20 years. However, this finding was inconsistent with a study done by Kabir et alwhere majority of the workers had a work experience duration of 5 years or less. This discrepancy could have been because workers with longer work experience dropped out of quarry work because of the severity of respiratory symptoms and could no longer work in the quarry after 5 years.

Limitations

Data collection for this study was done at a time when there was a global outbreak of COVID-19 disease. Some quarry workers were hesitant to do the spirometry test and have their respiratory symptoms assessed by a clinician for fear that the collected information could be used to their disadvantage, for example, take them to government quarantine centers if their symptoms resembled those of COVID-19. Others feared that they would be fired if the spirometry test showed abnormal pulmonary function because quarry work is manual and workers should be fit in order to work efficiently. The researcher had to spend a lot of time assuring them that the study was conducted solely for academic purposes and information generated would be regarded with utmost confidentiality.

CONCLUSION

National environment management authority in collaboration with the County Government of Nairobi department of Environment should conduct routine particulate matter monitoring in Nairobi quarries to provide data that can inform decisions on air pollution control actions such as setting permissible exposure limits for respirable dust in quarries. There are several dust-related adverse respiratory symptoms reported by quarry workers who work in dusty environments and to mitigate this, the Government should enforce occupation health and safety Act in order to promote healthy work environments in quarries. To protect quarry workers from prolonged exposure to dust, quarry owners should be mandated to adopt point source dust control measures to trap large quantities of dust before they can escape into the atmosphere. Such measures include the use of filters, scrubbers and precipitators to trap dust emissions. The Government should make it mandatory for quarry owners to provide the quarry workers with respiratory masks and

other dust PPE and enforce workers to use such PPE at all times during quarrying processes.

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