JMSCR Vol.||03||Issue||08||Page 7150-7160||August 2015

www.jmscr.igmpublication.org
Impact Factor 3.79
ISSN (e)-2347-176x
crossref DOI: _http://dx.doi.org/10.18535/jmscr/v3i8.41

Journal Of Medical Science And Clinical Research
IGM Publication
An Official Publication Of IGM Publication

Effect of Cement Dust Exposure on Lung Function among Residents of Kalambaina Community in Sokoto State, Nigeria

Authors
Merenu IA[1] Omokhodion F[2] Mojiminiyi FBO[3] Ibrahim MTO[1]
[1]Department of Community Health, Usmanu Danfodiyo University Sokoto, Nigeria
[2]Department of Community Medicine, University College Hospital Ibadan, Nigeria
[3]Department of Physiology, Usmanu Danfodiyo University Sokoto Nigeria
Corresponding Author
MERENU, Irene Adanta
Department of Community Health, Usmanu Danfodiyo University Teaching Hospital Sokoto, Sokoto State, Nigeria
Email: *merenuirene@yahoo.com, Tel: 234-08035071910*

ABSTRACT

Background: *The health of communities living around industrial areas has been a cause for concern. Effluents and emissions produced in these areas have been shown to affect health of these communities adversely. Across the world, industrial disasters have affected host communities. Cement manufacture causes environmental impacts at all stages of its production. These include emissions of airborne pollutants in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries. Many of these air pollutants have been associated with increased respiratory morbidity and mortality across all age groups.*

Objective: *This study investigated the effect of cement dust exposure on lung function among residents of Kalambaina community in Sokoto State, Nigeria.*

Methodology: *A total of 514 respondents participated in the study; 244 residents of Kalambaina, the host community of the cement factory and 270 in the non exposed group, residents of Gidan Madi, a community that has neither cement nor any other dust generating factory. Gidan Madi is 70km away from the cement factory. Both communities are rural and socio-culturally similar.*

The study employed a comparative cross- sectional analytical design. An interviewer - administered semi-structured questionnaire was used to collect information on socio-demographic parameters, and exposure to cement dust. It also inquired about habits like cigarette smoking and history of exposure to dusty jobs. Physical examination of the subjects included measurements of weight, height, blood pressure and pulse rate. Spirometry was used to assess lung functions. Data analysis was carried out using SPSS 15.0 for windows (Inc., Chicago, USA, 2001). The results were recorded as mean ± standard deviation (SD). The P- value was taken as statistically significant at $P < 0.05$.

Results: *The FVC, FEV_1 and FEV_1% were significantly lower in the exposed subjects ($P = 0.0001$, $P = 0.024$ and $P = 0.0002$ respectively). There was however, no statistically significant difference in the PEFR ($P = 0.095$). Linear regression of the lung function parameters and the duration of exposure or stay in Kalambaina community showed negative correlation. The pattern of obstructive lung function among respondents in both exposed and non exposed communities showed significantly higher prevalence in the exposed community than in the non exposed community ($P = 0.0215$).*

Conclusion: *The result of this study suggests that the health of residents of Kalambaina the host community of* *the cement factory was adversely affected by the chronic exposure to cement dust. The lung functions of residents of Kalambaina were adversely affected as shown by the depressed indices of their lung functions compared to those of residents of Gidan Madi the non exposed community. The results of the present study suggest that chronic exposure to cement dust has adverse health effects on the respiratory system.*

Key-words: *Silica, Cement dust, lung function, air pollution, Nigeria.*

Introduction

The health of communities living around industrial areas has been a cause for concern. Effluents and emissions produced in these areas have been shown to affect health of these communities adversely. [1] Cement manufacture causes environmental impacts at all stages of its production. These include emissions of airborne pollutants in the form of dust, gases, noise and vibration when operating machinery and during blasting in quarries.[2] Many of these air pollutants have been associated with increased respiratory morbidity and mortality across all age groups.[3-5] Cement manufacture has been carried out on a large scale, since 1967 in Sokoto State, its impact on the health of residents especially on long term basis warrants attention and needs to be investigated.

Some researchers in Nigeria have studied the effect of chronic exposure to cement dust on the health of cement factory workers and have found cement dust deleterious to health. [6-11] Oguntoke and his colleagues in their study in Ewekoro Local Government Area, South-Western Nigeria on both cement factory workers and residents of Ewekoro found that the health profile of the factory workers and some residents of neighbouring communities showed high levels of respiratory and skin infections.[12]

A study carried out on the workers of this cement factory in Kalambaina found that cement dust was deleterious to health of the workers.[6,7] The study found the vital capacity and forced expiratory volume for one second percent [FEV_1%] were found to be significantly lower in the cement factory workers than in the control subjects. The haemoglobin concentration and packed cell volume were significantly lower than those of the control group while the white cell count and platelets were significantly higher in the cement factory workers than in the control group. The liver enzymes were not significantly different except for alkaline phosphatase which was significantly lower in the cement factory workers than in the control subjects.[6,7] If these effects were reported in cement factory workers who are aware of the health risks of cement dust and claim to use protective devices, the fate of residents in the host communities, who are unaware of the health risks and use no protective devices should be of great concern. There is need to assess the lung function of these residents.

Some workers have postulated that cement dust is inert and harmless to humans and animals. In a 1987 review of literature, Holt[12]reported that Portland cement has no adverse effect on health of cement workers in England. Some reports support this view. Thomson, [13] in a study on the health of workers in dusty trades in Washington DC, found no negative effect of cement dust on health. Siziya[14] working in Zambia also observed no association between cement dust and lung function impairment. His exposed individuals were 62% less likely to have had impaired lung function than his controls. However, contrary to these observations of no adverse effects, a growing body of literature found that cement dust is toxic to the lungs and suggest that chronic cement dust exposure may be toxic to the body. [6,,8,15-18] The effect of cement dust exposure on health appears controversial implying the need for more work to be done.

This study investigated the effect of cement dust exposure on lung function among residents of Kalambaina community in Sokoto State, Nigeria.

Materials and Methods

This study was embarked upon following ethical approval obtained from the Usmanu Danfodiyo University Teaching Hospital Research Ethics

Committee. Kalambaina the host community of the cement factory is one of the 10 political wards in Wamakko LGA of Sokoto State. Kalambina is divided into 22 settlement areas. It is a rural community. The non exposed community, Gidan Madi is one of the 10 political wards of Tangaza LGA of Sokoto State. It is also rural and is socio culturally similar to Kalambaina. It is 70 kilometres away from Kalambaina and has no cement factory nor any factory that can emit dust.

Data Collection Methods

An interviewer administered questionnaire in the local language, elicited information on socio-economic and demographic parameters and exposure to cement dust. Inclusion criteria were that the respondents must have resided in the study area for at least 5years. He or she must be between the ages of 18 to 80 years, must be a non smoker, not a worker in a dusty trade and must not have respiratory infections. The non exposed group was chosen from individuals who have similar socioeconomic and demographic parameters as the exposed community.

Measurement of Anthropometric parameters: The Height was measured in centimetres according to the National Health and Nutrition Examination Survey (NHANES) protocol.[19] Weight was measured in kilograms with minimum clothing and bare feet, with subject standing in the centre of the scale, with hands by the sides, in accordance with the NHANES protocolusing an electronic weighing scale. [19]

The blood pressure in millimetres of mercury was measured using a standard mercury sphygmomanometer. The pulse rate was also taken in beats per minuites.[20] This was done from the radial artery in the wrist using a wrist watch and counting for one minute.

Lung function tests

These include peak expiratory flow rate [PEFR], forced vital capacity [FVC], forced expiratory volume in one second (FEV_1), and forced expiratory volume in one second per cent [FEV_1%]. Spirometry was carried out with digital spirometer, the One Flow Soft 1.4 (Clement Clarke International Essex, England). The purpose and technique employed was explained and demonstrated to the respondents. They were allowed to make trial manoeuvres. During each manoeuvre, the respondent was observed for compliance with instructions. The recording was done with each respondent sitting, (to avoid any fainting or syncopal attacks) relaxed and upright in front of the spirometer, with the lips firmly applied around the disposable cardboard mouthpiece. Care was taken to ensure that there was no leakage of air around the mouthpiece. The subject was instructed to breathe in maximally and to expire as forcefully and rapidly as possible into the spirometer until instructed to stop. Recording was taken after three practice attempts. PEFR, FVC, FEV_1 and FEV_1% were read off and the best of three spirograms was recorded. To protect the respondent one disposable card board mouth piece was used per respondent.

Results

Questionnaire response rate: of the 540 respondents projected for enrolment into the study, 514 participated in the study; 244 from the exposed community (Kalambaina, the host community of the cement factory) and 270 from the non exposed community (Gidan Madi) giving an overall response rate of 95.2%.

Tables 1: Shows the socio-demographic parameters of the Exposed and Non- Exposed communities.

There were no statistically significant difference in the age, distribution of the two communities ($P>0.05$). Of the 244 respondents in Kalambaina, 14, (5.7%) were females. Out of the 270 respondents in the control community, 12 (4.4%) were females. The ratio of females to males for the two communities was 1:18 for Kalambaina 1:17 . Gidan Madi 1:22. The gender distribution in the two communities was similar. Of the total respondents 4.5% had uncompleted primary or no education whatsoever. However, majority of the respondents, 70.0% had only quranic education. 1.6% however had tertiary education. The majority of the educated, 11.3% had completed primary education or uncompleted secondary education whilst 10.3% had uncompleted tertiary and complete secondary school education. There was statistical significant difference between the two communities in educational attainment. The non exposed community had higher educational attainment than the exposed community (P=0.04). Farming was the major occupation of the respondents as 48% of them were farmers. 32.5% were traders and very few 4.3%, were artisans. Civil servants made up 6.6%. There were significantly more farmers, artisans and civil servants in the non-exposed community than in the exposed community (p<0.003). The dominant ethnic group in the two communities was Hausa; accounting for 94.3% of the exposed Subjects and 96.7% of the non exposed community. Of the total respondents 95.5% were Hausas. Fulanis were 4.1% of all the respondents. Other tribes made up 0.4% of total respondents. The two communities had similar ethnic group distribution. The P value indicated that the difference was not statistically significant. The exposed Subjects were 100% Muslims while 98.9% of the non exposed were Muslims with 1.1% Christians. The religious inclination of the two communities was similar (p< 0.2839).

Table1: Socio – demographic parameters of Respondents (Exposed and Non- Exposed communities)

AGE in years	Exposed n=244 Frequency (%)	Non-Exposed n=270 frequency(%)	Total n=514 frequency (%)	Test statistics P value
18- 35	148 (60.6)	159 (58.9)	307 (59.7)	
36- 55	71 (29.1)	95 (35.2)	166 (32.3)	χ= 11.545
56 – 80	25 (10.3)	16 (5.9)	41 (8)	p= 0.0729
Total	244(100)	270 (100)	514 (100)	
Gender				
Males	230 (94.3)	258 (95.6)	488 (94.9)	χ^2= 0.2177
Females	14 (5.7)	12 (4.4)	26 (5.1)	p= 0.6408
Total	244 (100)	270 (100)	514 (100)	
Educational Attainment				
None/ Primary uncompleted	14 (5.7)	9 (3.3)	23 (4.5)	
Primar completed/Secondary uncompleted	18 (7.4)	40 (14.8)	58 (11.3)	χ^2= 22.070
Secondar completed/ Tertiary uncompleted	18 (7.4)	35 (13)	53 (10.3)	p=0.04
Tertiary completed	2 (0.8)	6 (2.2)	8 (1.6)	
Vocational school	2 (0.8)	10 (3.7)	12 (2.3)	
Quranic education only	190 (77.9)	170 (63.0)	360 (70.0)	
Total	244 (100)	270 (100)	514 (100)	
Occupation				
Farming	139 (57.0)	108 (40)	247 (48)	
Trading	72 (29.5)	95 (35.2)	167 (32.5)	χ= 26.492
Artisan	2 (0.8)	20 (7.4)	22 (4.3)	p= 0.0031
Student	21 (8.6)	21 (7.8)	42 (8.2)	
Civil Servant	10 (4.1)	24 (8.9)	34 (6.6)	
Total	244(100)	270(100)	514(100)	
Ethnicity				
Hausa	230 (94.3)	261 (96.7)	491 (95.5)	χ^2= 4.988
Fulani	14 (5.7)	7 (2.6)	21 (4.1)	p= 0.0826
Others	0 (0)	2 (0.7)	2 (0.4)	
Total	244 (100)	270 (100)	514 (100)	
Religion				
Islam	244 (100)	267(98.9)	511 (99.4)	χ^2= 1.148
Christianity	0(0)	3(1.1)	3 (0.6)	p= 0.2839
Total	244 (100)	270 (100)	514 (100)	

Anthropometric Parameters of Exposed and Non exposed Subjects

Table 2: Anthropometric Parameters of Exposed and Non- exposed Subjects

Variable	Exposed Subjects n=(244)	Non- Exposed n=(270)	Statistics t test	degrees of freedom	95% CI	p-value
Age range	18-80yrs.	18-75yrs.				
Mean Age yrs. ± sd	35.7±13.6	35.2 ±11.5	0.45	512	-2.68 to 1.68	0.65
Weight range(kg)	29-103	37-105				
Weight kg mean ± sd	61.3 ± 11.4	60.9 ± 9.6	0.43	512	-2.22 to 1.42	0.67
Height range	135-190cm	150-190cm				
Height cm. mean ± sd	172.1±5.9	173.8±5.9	0.134	512	-2.27 to 1.77	>0.1

The anthropometric paramaters of the exposed and non exposed subjects as presented on Table2. shows that anthropometrically, the exposed and the non exposed subjects were marched for age, weight and height (P>0.05)

The age range of the respondents was 18 to 80 years. The age range for Kalambaina community was 18-80years and that of the Gidan Madi was 18-75years. There were no significant differences in the anthropometric parameters of the respondents in the two communities (P = 0.65, 0.67, and >0.1) for age, weight and height respectively. The mean age and standard deviation for Kalambaina community was 35.7 ± 13.6 years and that of the non exposed community (Gidan Madi) was 35.2 ± 11.5 years.

Table 3: Lung Function of Exposed and Non exposed Subjects

Parameter	Exposed Subjects mean ±sd (n =244)	Non exposed mean ±sd (n= 270)	t test	degrees of freedom	95% CI	p value
FVC [L]	2.5 ±1.19	2.9 ±1.0	4.14	512	0.21to 0.59	0.0001
FEV_1 [L]	2.2 ±1.1	2.4 ±0.9	2.26	512	0.03to 0.37	0.024
FEV_1%	84.9 ± 15.6	90.1 ± 15.3	3.81	512	-7.88 to -2.52	0.0002
PEFR [L/Min]	328.9 ±129.7	348.4 ±133.7	1.68	512	-3.38 to 42.38	0.095

Table 3 Shows the FVC , FEV_1 and FEV_1% were significantly lower in the study subjects P <0.001 for FVC, 0.024 for FEV_1, and 0.0002 for FEV_1% . There was however, no statistically significant difference in the PEFR (P= 0.095).

Figures 1-4 show the Linear Regression, analysis of the relationship between the lung parameters FVC, FEV_1,FEV_1% and PEFR with years of exposure or length of stay in kalambaina (study community). The regression result showed depression of lung function with length of exposure. The correlation coefficient shows the rate of decline per year. For FVC Correlation coefficient (r) = -0.4715. P < 0.0001. For FEV_1 Correlation coefficient (r) = -0.5941. P < 0.0001. For FEV_1% Correlation coefficient (r) = -0.1817. P< 0.0046. For PEFR Correlation coefficient (r) = -0.5585. P < 0.0001.

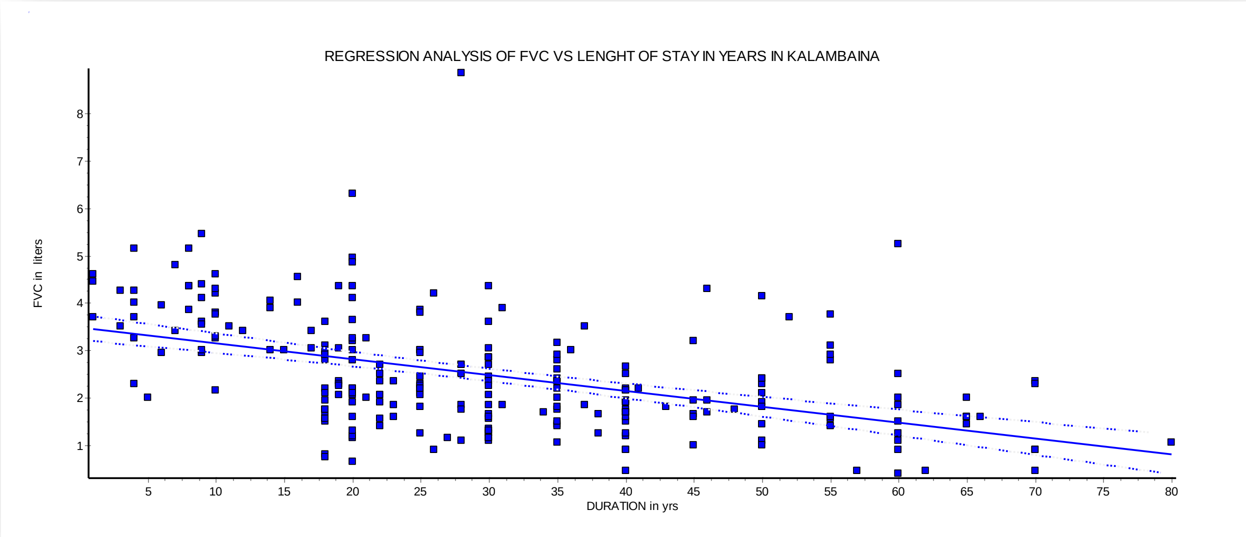

Figure 1 Regression analysis of FVC vs length of stay in years in Kalambaina
Correlation coefficient (r) = -0.4715. r squared = 0.2223 P < 0.0001

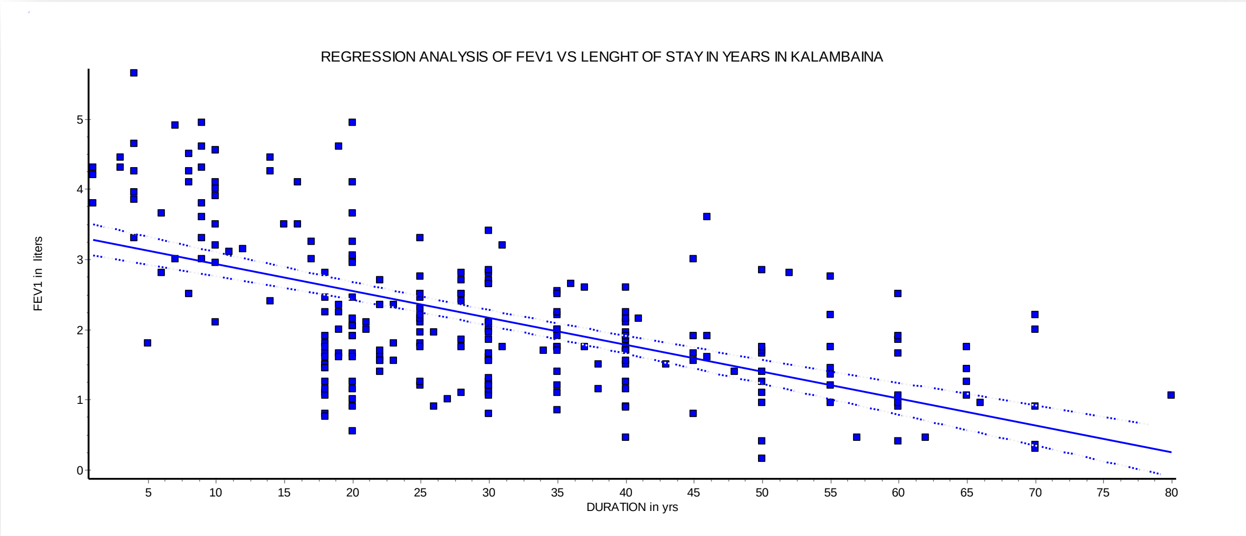

Figure 2 Regression analysis of FEV_1 vs length of stay in years in Kalambaina
Correlation coefficient (r) = -0.5941. r squared = 0.3530 P < 0.0001

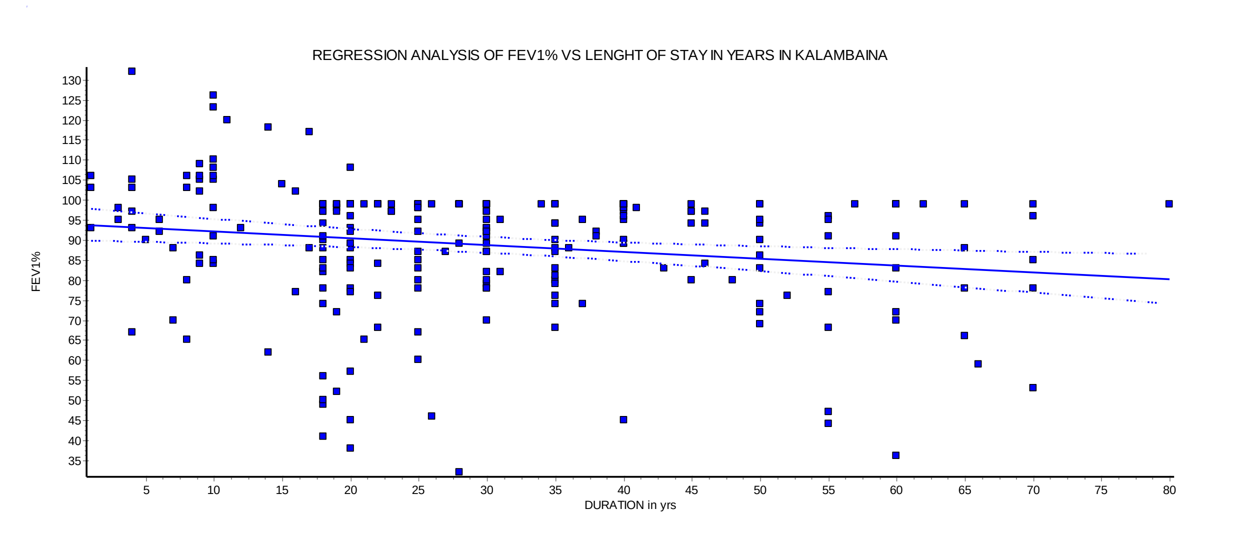

Figure 3 Regression analysis of FEV1% vs length of stay in years in Kalambaina
Correlation coefficient (r) = -0.1817. r squared = 0.03300 P< 0.0046

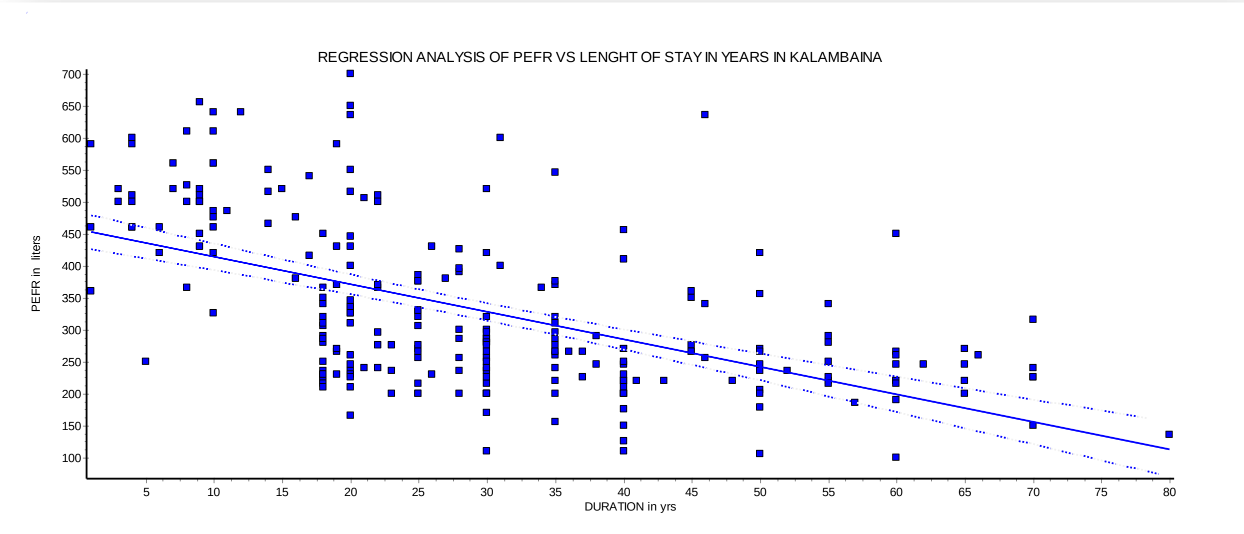

Figure 4 Regression analysis of PEFR vs length of stay in years in Kalambaina
Correlation coefficient (r) = -0.5585. r squared = 0.3119 P < 0.0001,

Pattern of Lung Function Abnormality Among exposed and non exposed Subjects

Table 4 Pattern of Lung Function Abnormality Among exposed and Non exposed Communities

Pattern	exposed Subjects n(%)	Non exposed n(%)	Total n(%)
Obstructive	42 (17.2)	21 (7.8)	63(12.3)
Normal	202 (82.8)	249(92.2)	451(87.7)
Total	244 (100)	270 (100)	514 (100)

Obstructive: $FEV_1\% < 70\%$

Normal: $FEV_1\% > 70\%$

Fisher's Exact Test . p< 0.0215. Odds ratio= 0.5112

Table 4 shows the pattern of lung function abnormality among respondents in both exposed and non exposed communities. The non exposed subjects had significantly lower risk of having obstructive lung function than the exposed subjects. Of all the respondents (12.3%) had

FEV_1% lower than70%. 21 of the non exposed Subjects (7.8%) had FEV_1% lower than 70% while 42 (17.2%.) respondents from the exposed community had FEV_1% lower than70% . Two hundred and two (82.2%) of the exposed Subjects and 249 or 92.2% of the non exposed group did not show evidence of obstructive lung disease. These respondents had $FEV_1\% \geq 70\%$.

Discussion

The decrease in the FEV_1 and FVC and FEV_1% in the exposed community is suggestive of lung function impairment.[21] The findings on pulmonary function parameters (the VC (vital capacity), FVC, FEV_1, FEV_1/VC ratio and PEFR values) in the study carried out by Yang[22] and his colleagues are consistent with the findings in this study. The findings by Al – Neaimi[16] and others, [6,17] were also similar to the findings in this study. These studies on cement dust exposure have demonstrated the observation of lower pulmonary function indices and impaired lung function. [6, 16] These studies were all carried out among cement workers unlike the current study which was carried out on residents or host communities of a cement factory.

However, Oguntoke and his colleagues in their study in Ewekoro Local Government Area, South-Western Nigeria on both cement factory workers and residents of Ewekoro found that the health profile of the factory workers and some residents of neighbouring communities showed high levels of respiratory and skin infections.[12] In Israel, Goren and his colleagues[23] in their study on respiratory problems associated with exposure to air borne particles in school children in two communities (exposed and non-exposed to cement dust pollution) did not find consistent trend of reduced pulmonary function indices among children who lived in polluted community. However, PEFR was reported to have been significantly lower among these children, and a higher prevalence of most respiratory symptoms was observed among them in contrast to children in the unexposed community. The HSE (1994)[24] review described evidence for an increased risk of chronic bronchitis and impairment of pulmonary function (consistent with chronic obstructive pulmonary disease) in cement dust exposed workers, but there was a lack of data on dose-response relationships.

Most epidemiologic studies of pulmonary function and occupational exposure to respirable crystalline silica are cross-sectional studies that do not provide quantitative modelling of cumulative dust exposure. They report occupationally related annual declines in ventilatory functions in workers with and without silicosis [i.e., gold and other hard rock miners, iron ore miners, cement, coal, talc and slate workers].[25-28] Thirteen studies with quantitative dust exposure for four silica exposed cohorts found statistically significant association between loss of lung function [i.e., FEV_1, FVC] and cumulative respirable dust exposure in coal miners and South African gold miners.[25-28] Hnizdo[28] estimated that a 50 year old white South African gold miner [non-smoker] who was exposed to gold mine dust [containing 0.09mg/m^3 of crystalline silica] of an average respirable concentration of 0.3mg/m^3 for 24years would lose 236ml of FEV_1. The combined effects of respirable dust exposure and smoking on the loss of FEV_1 were found to be additive.[25, 29]

The negative correlation coefficient values for the relationship between lung function parameters and duration of exposure found in this study validates the studies of other researchers who found lung function to deteriorate with prolonged exposure to cement dust. [10,15] It also tallies with findings of researchers who say lung function declines with age [30,31]

The findings of various workers on the various lung parameters however has varied; for example Merenu [6] et al found the (VC) vital capacity and forced expiratory volume for one second per cent (FEV_1%) significantly lower in cement factory workers than in the control subjects while the FVC and PEFR were similar. In the study by Alakija [10] on cement factory workers, FEV_1 was significantly lower in cement factory workers than in their control group , just as in this study, whilst Azah,[32]found FVC, FEV_1 lower in dust exposed subjects than in their control group but with FEV_1% not significantly different. Al-Neaimi[16] and Yang,[22] found significant reduction in VC, FVC,FEV_1 and PEFR in their cement dust exposed subjects. This underscores the importance of measuring several lung function indices in comparative studies such as this.

Conclusion

The findings of this study showed significantly lower values of FVC, FEV_1, suggestive of higher prevalence of probable lung function impairment and, a significantly higher mean value of FEV_1% which may suggest a restrictive pattern of lung disease in the study community. A significantly larger proportion of subjects with FEV_1% <70%, was observed among the exposed subjects than in the non exposed subjects, implying a higher incidence of obstructive lung function in the community exposed to cement dust, than the non cement dust exposed community.

Recommendations

To safeguard the health of cement dust exposed communities, it is suggested that cement factories acquire more effective dust emission control equipment to curb the level of cement dust emission into the environment. Periodic monitoring of dust level in the host communities will go a long way to improve air quality in the environment and operate within acceptable levels.

The health department of the local government of this host community should ensure the reduction to acceptable level, the emissions produced by this factory to reduce the occurrence of health hazards among the residents.

Acknowledgement

We wish to appreciate the help of two technologists in the department of physiology of Usmanu Danfodiyo University Sokoto who helped with data collection Mr Alexander Anya Isu and Mrs Esther Igbokwe.

We are greatly indebted to Professor Chibueze Njoku, a Pulmonologist in the Department of Internal Medicine of Usmanu Danfodiyo University Teaching Hospital Sokoto, who provided the digital spirometer used for this study.

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Competing interests

The authors declare that they had no competing interests.

Author's contributions:

Merenu IA and Mojiminiyi FBO designed the study. Omokhodion F, Mojiminiyi FBO and Ibrahim MTO supervised the project. Merenu IA wrote the manuscript and all the authors read and approved the final version of the manuscript.