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Original Research Article

Respiratory Health Effects of Occupational Exposure to Hazards of Public Waste in Cross River, Nigeria

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Abstract

Public waste disposal workers in Cross River State do not take precautionary measures and are exposed to waste that generates gases, dust and microorganisms. Spirometry and respiratory symptoms in public waste workers in Cross River state, Nigeria was studied with the aid of a spirometer and questionnaire respectively. Dust and gases (NO_2, SO_2, H_2S and FL) emitted from the vicinity were also studied. Two hundred and forty (240) male subjects were used for the study comprising 120 test and 120 control subjects with similar anthropometric parameters. Results showed that the mean FVC (Liters) in the test subjects was significantly reduced ($p<0.01$) compared to the control. Mean FEV_1 (liter) of the test group was significantly lower ($p<0.001$) than control. Result for FEV_1% (Liters) and PEFR (L/min) in the test subjects was not significantly different compared to control. Percentage of oxygen saturation (SPO_2%) in both control and test subjects were not significantly different. Dust levels (mg/m3) in the test sites was significantly higher ($p<0.001$) than in control sites. SO_2, NO_2 and H_2S were significantly higher in test sites compared to control ($p<0.05$-$p<0.01$). There was a higher incidence of respiratory symptoms such as productive cough, sneezing etc in public waste workers. Public waste workers had a restrictive pattern of impairment caused likely by significantly high dust levels with SO_2 level which exceeded the ambient levels as documented by the Federal Ministry of Environment in Nigeria

Keywords: Respiratory symptoms, public waste, spirometry, dust, gases, subjects.

INTRODUCTION

Public waste includes waste produced from residences, commercial entities, markets, industries etc [1, 2]. Waste composition varies with the major properties that constitutes its physical characteristics which include: density, distribution of component sizes, content of moisture, colour, voids, appearance of individual parts and visual attribute amongst others [3]. In developing countries like Nigeria, Cross River State as is the case with most states, waste accumulates at the dumping sites requiring being shoveled or picked up, thus requiring more direct contact of workers with public waste, a situation that is further compounded by the fact that public waste disposal workers in developing countries rarely adhere to occupational protection guidelines like wearing face mask and gloves and are thus largely exposed to occupational health hazards including dust from waste disposal activities and toxic gases from decomposing waste [4].

Many worldwide epidemiological studies have shown a relationship between occupational exposure and adverse health effects including respiratory problems [5, 6]. Also, some previous studies in developing countries have also suggested a link between the activities of disposing waste and lung function impairment [7, 2].

Although, a number of researches on the effects of occupational exposure have been undertaken worldwide with refuse disposal workers, in Nigeria, it's possible that differences in climate, type and volume of waste generated, personal attribute of the workers and the concentration of gases in the vicinity of refuse sites will produce respiratory function impairments which differ from those of waste workers in developed countries, a reason which necessitated the present study to investigate the respiratory symptoms and lung function following exposure to the hazards of disposing public waste.

MATERIALS AND METHODS

Study Subjects and Sites selection

The study was carried out on one hundred and twenty male public waste disposal workers in Cross River State, Nigeria which formed the test subjects and the control which comprised one hundred and twenty male residents that are by occupation civil servants and were not exposed to the occupational hazards of waste disposal or any other known air pollutant. Control subjects were of similar age, height, body weight and chest circumference with the test subjects since these anthropometric parameters affect lung function.

The sites in Cross River State selected for the study were towns with increased populations so as to ensure generation of large volumes of waste. Participants were non-smoking males and were included in the study based on absence of any past history of respiratory disease. Subjects with heart and spine infections together with deformities that are spine related were excluded from the study. The study was after approval was given by the State Ministry of Health, Cross River State, Nigeria. All participants gave their consent to participate in the study.

METHODOLOGY

The subjects were educated on the relevance and significance of the study to enable them grasp the procedures involved. All the steps of the study were demonstrated to allay the fears of the subjects and questions were entertained. Subjects who gave their consent to participate were administered with a modified respiratory disease questionnaire produced by the British medical council. The questionnaire recorded the name, sex, age, occupation, smoking habits (if applicable), duration of service, history of respiratory symptoms and cardio-pulmonary disease.

Collection of environmental data indicative of exposure: personal dust and gas sampling

Exposure data for personal dust and gas levels were obtained at both control and test sites. A Universal sample pump (SKC Inc, USA) was used for personal dust collection. The instrument measured the concentration of respirable dust less than particulate $matter_{2.5}$ using pre-weighed PVC filters, in Cyclone heads as it maintains a constant supply of air at 2L/min through its filter for 4 hours. The filter paper was weighed before sampling and recorded as the initial weight. After sampling the filter paper was then weighed again and its weight was recorded as the final weight. Particulate matter was documented as the difference between final and initial body weights.

A Gasman portable gas monitor (Crowcon Detection instruments Ltd UK), was used to measure the ambient concentrations of sulphur (iv)oxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulphide (H_2S) and flammable gas. The monitor works by gas diffusion into the sensor which is placed directly under the filter. When the atmospheric air under analysis comes in contact with the sensor, an electrochemical reaction occurs and the current generated or consumed is amplified and displayed on the LCD (liquid crystal display).

Measurement of Lung function

Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), peak expiratory flow rate (PEFR) and FEV_1/FVC ratio were the indices used to assess lung function. This procedure was done using a spirometer by contec medical systems co. Ltd, China. The method of testing was carefully demonstrated to each participant that gave his consent. Each subject was asked to sit on a straight back chair and breathe in as deeply as possible, after which with the lips firmly around the disposable mouth piece, the subject then breathed out quickly and forcefully into the spirometer. Each subject was made to perform the procedure three times with a minute rest in between trials after which the best of the three readings was recorded. Percentage saturation of oxygen of the subjects was measured using a pulse oximeter.

Statistical analysis

The Graph pad prism version 7.01 statistical software was used for analysis. Chi square was used to compare percentages or ratios. Results were expressed as mean ± SEM. Coefficient of correlation (r) was used to determine the significance between relationships. Unpaired students t test was used to compare two means. P values less than 0.05 was considered statistically significant.

RESULTS

Respiratory symptoms

Table-1 shows the result for comparison of respiratory symptoms between the control and test subjects. Of all the respiratory symptoms, productive cough, sneezing, catarrh and chest pain accounted for the highest prevalence (51.67percent vs 23.33percent , 56.67percent vs 9.17percent, 54.17percent vs 28.33percent and 45.83percent vs 5.83percent) in the test subjects which were significantly higher ($p<0.001$) compared to the control.

Table-1: Respiratory symptoms in control and test subjects

	Control		Test		Chi	p-value
	n	percent	n	percent		
Pro cough	11	9.17	62	51.67	51.205	***
Unprod cough	8	6.67	43	35.83	30.501	***
Chest pain	7	5.83	55	45.83	50.105	***
Dypnea	4	3.33	22	18.33	13.975	***
Sneezing	28	23.33	68	56.67	27.778	***
Catarrh	34	28.33	65	54.17	16.523	***

Wheezing	3	2.50	11	9.17	4.855	*
Asthma	1	0.83	1	0.83	0.000	NS

***= $P<0.001$, ** = $P<0.01$, * = $P<0.05$, NS= not significant

Personal dust and gas levels

Figure-1 shows the comparison of mean particulate matter in refuse disposal sites and control sites. Mean particulate matter levels in refuse disposal sites (0.50± 0.04 mg/m3) was significantly higher ($p<0.001$) compared to control site (0.17± 0.01 mg/m3).

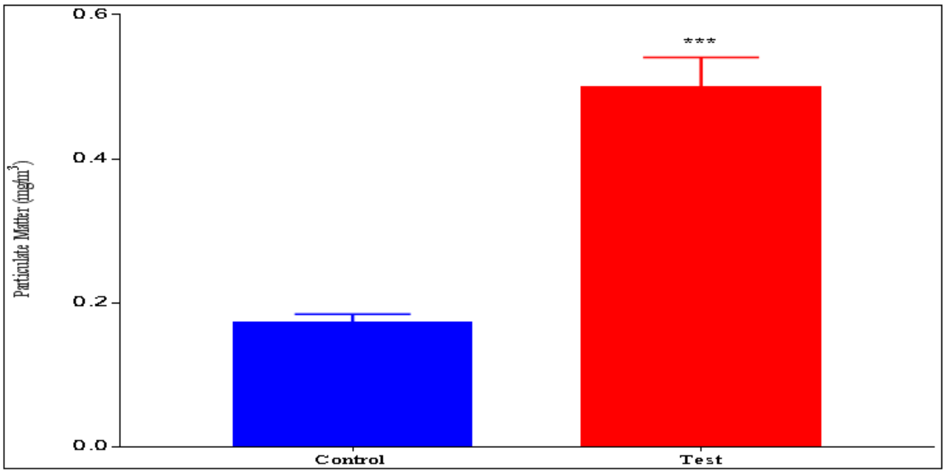

Fig-1: Comparison of particulate matter levels in test and control site

Value are expressed in mean±SEM, n=6, ***significantly different from control at $p<0.001$

Mean nitrogen dioxide (NO_2) concentration in the refuse disposal sites (0.23± 0.02 ppm) was significantly higher ($p<0.05$) than that in control site (0.17± 0.02 ppm). Figure 2

When mean sulphur dioxide (SO_2) concentration was compared in refuse disposal (2.00±0.00 ppm) and control (1.17±0.28 ppm) sites, result showed a significantly ($p<0.01$) higher concentration in refuse disposal sites compared to control (Figure-2).

Figure-2 also shows the comparison of mean hydrogen sulphide (H_2S) concentration in refuse disposal and control sites. H_2S concentration in refuse disposal sites (0.23±0.02 ppm) was significantly higher ($p<0.01$) compared to the control site (0.13± 0.02 ppm). There was no significant difference in Mean flammable gas (methane,FL) levels in refuse disposal (0.01±0.00ppm) and control (0.01 ± 0.00ppm) sites.

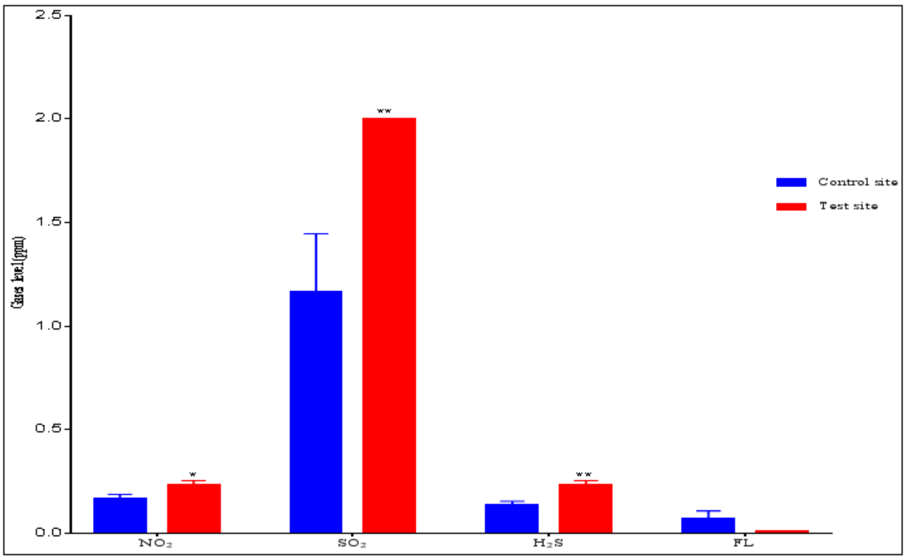

Fig-2: Comparison of levels of NO_2, SO_2, H_2S, and FL in control and test site

Value are expressed in mean±SEM, n=6, *significantly different from control at $p<0.05$, **significantly different from control at $p<0.001$

Comparison of concentrations of some gaseous pollutants in refuse disposal sites with Federal Ministry of Environment permissible limits

The Federal Ministry of Environment permissible limits for NO_2, SO_2 and H_2S are 0.8ppm, 0.5ppm and 8.0ppm. Of all the gaseous pollutants measured, only the mean SO_2 concentration in the refuse disposal site was higher than its permissible limit by a factor of 4 (Table-2).

Table-2: Comparison of concentrations of some gaseous pollutants in refuse disposal sites with Federal Ministry of Environment permissible limits

S/N	Gases	Mean values of test sites	Federal Ministry of Enviroment permissible limit
1.	NO_2 (ppm)	0.23	0.8
2.	SO_2 (ppm)	2.00	0.5
3.	H_2S (ppm)	0.23	8.0
4.	FL (LEL)	0.01	-

Lung Function

Figure 3 shows the comparison of the forced vital capacity (FVC) between the test and control subjects. The FVC of the test subjects (2.43± 0.06 Liters) was significantly reduced (p<0.01) compared to the control (2.70± 0.08 Liters).

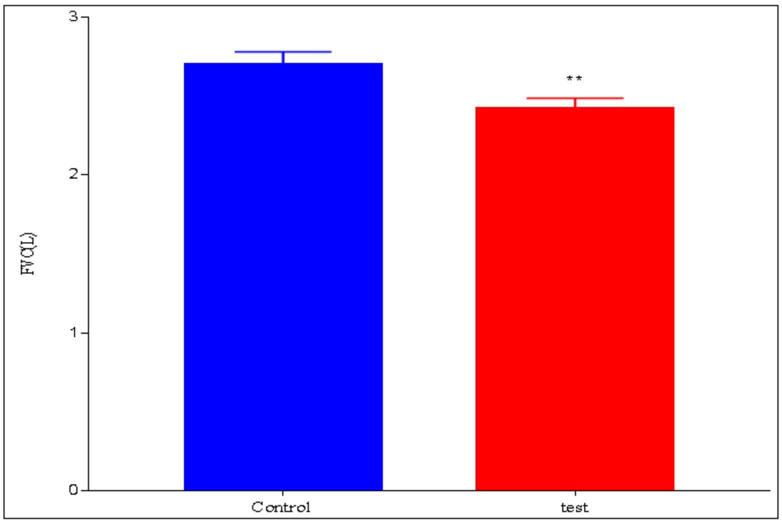

Fig-3: Comparison of forced vital capacity in control and test subjects

Values are expressed as mean±SEM, n=120, **significantly different from control at p<0.01

The FEV_1 of the test subjects (2.26± 0.06 liters) was reduced significantly (p<0.001) compared to that of control (2.56± 0.06 liters) (Figure-4).

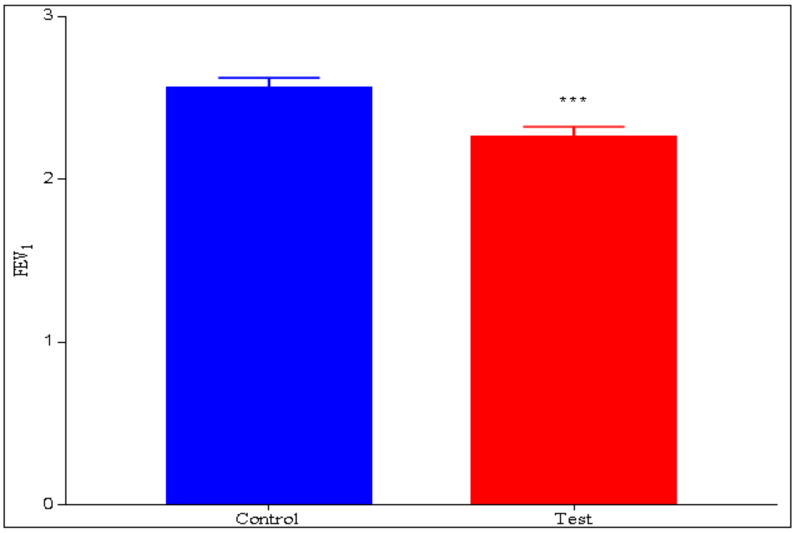

Fig-4: Comparison of forced expiratory volume in one second in control and test subjects

Values are expressed as mean±SEM, n=120, ***significantly different from control at p<0.0001

On the other hand, when a comparison of the results for percentage of forced expiratory volume in one second (FEV_1 percent) was made between the test (93.36± 1.14 liters) and control (96.68± 1.3 liters), the slight reduction of FEV_1 percent of the test was not significant compared to that of the control (Figure-5).

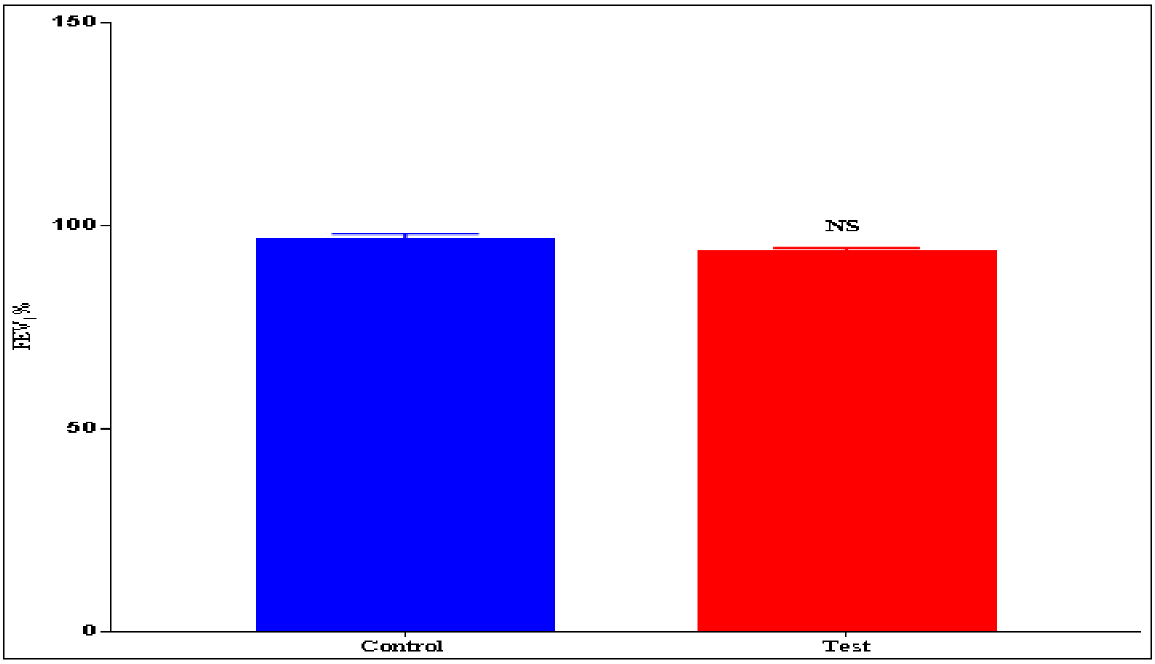

Fig-5: Comparison of percentage of forced expiratory volume in one second in control and test subjects
Values are expressed as mean±SEM, n=120, Not significantly different from control at p=0.0567

The peak expiratory flow rate (PEFR) of the test subjects and control subjects was also recorded (Figure-6). The PEFR of the test and control subjects were 6.17± 0.22 L/min and 5.63± 0.18 L/min respectively. The result of the test group was not significant (p=0.06) compared to control.

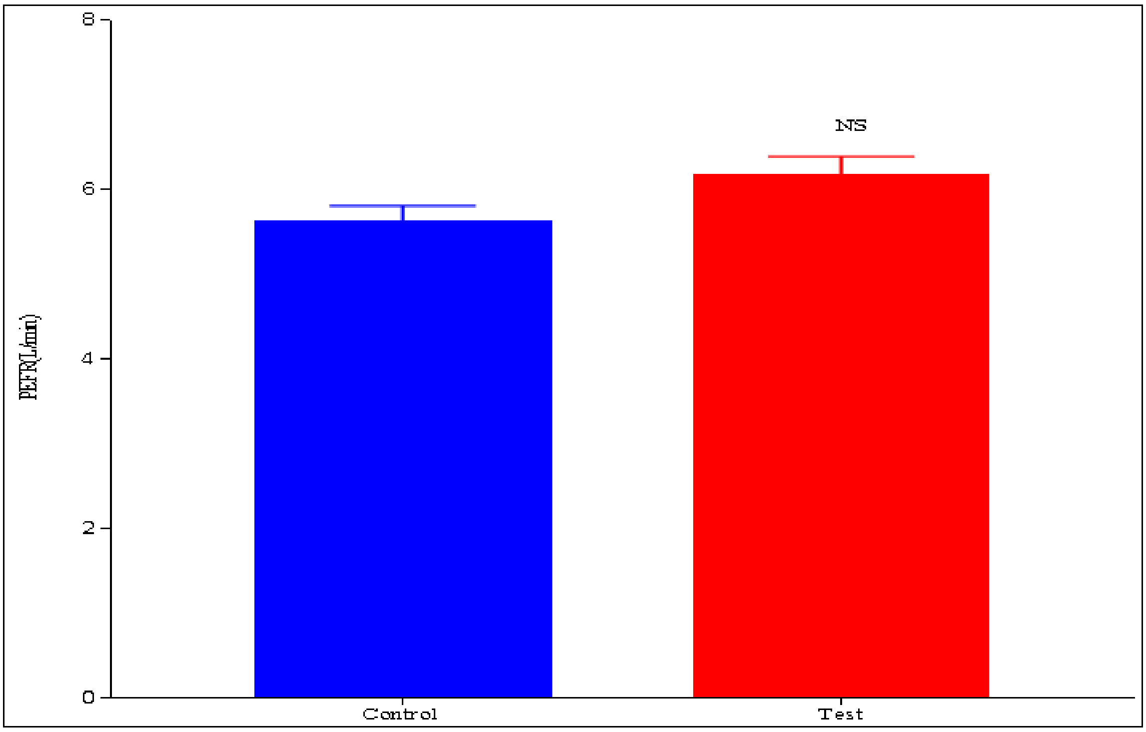

Fig-6: Comparison of peak expiratory flow rate in control and test subjects
Values are expressed as mean±SEM, n=120, Not significantly different from control at p=0.0632

Figure-7 shows the results for percentage oxygen saturation (SPO_2) in the control and test groups. The difference was not significant (p=0.07) when the SPO_2 of the test subjects (97.26± 0.11percent) was compared with control (97.57± 0.13percent).

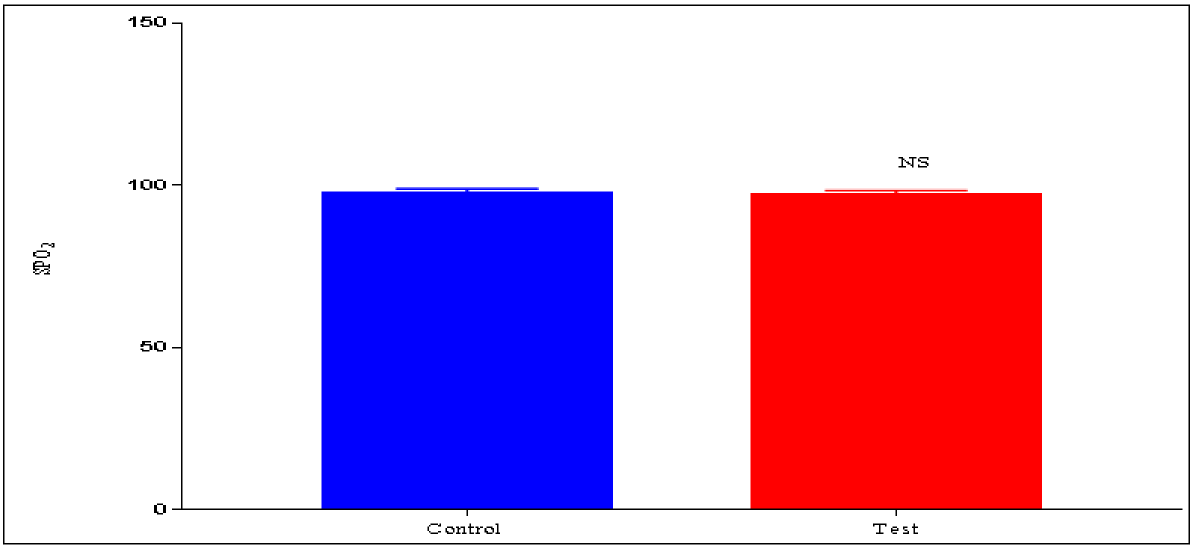

Fig-7: Comparison of percentage oxygen saturation in control and test subjects
Values are expressed as mean±SEM, n=120, Not significantly different from control at p=0.0963

Relationship between lung function indices and duration of service (length of exposure in the test subjects)

Figure-8 shows the association between duration of service (length of exposure to particulate matter and gaseous pollutants) and FVC among the test group. FVC values reduced with an increase in duration of service which showed a weak negative correlation(r=-0.06623) that was not significant (p=0.47).

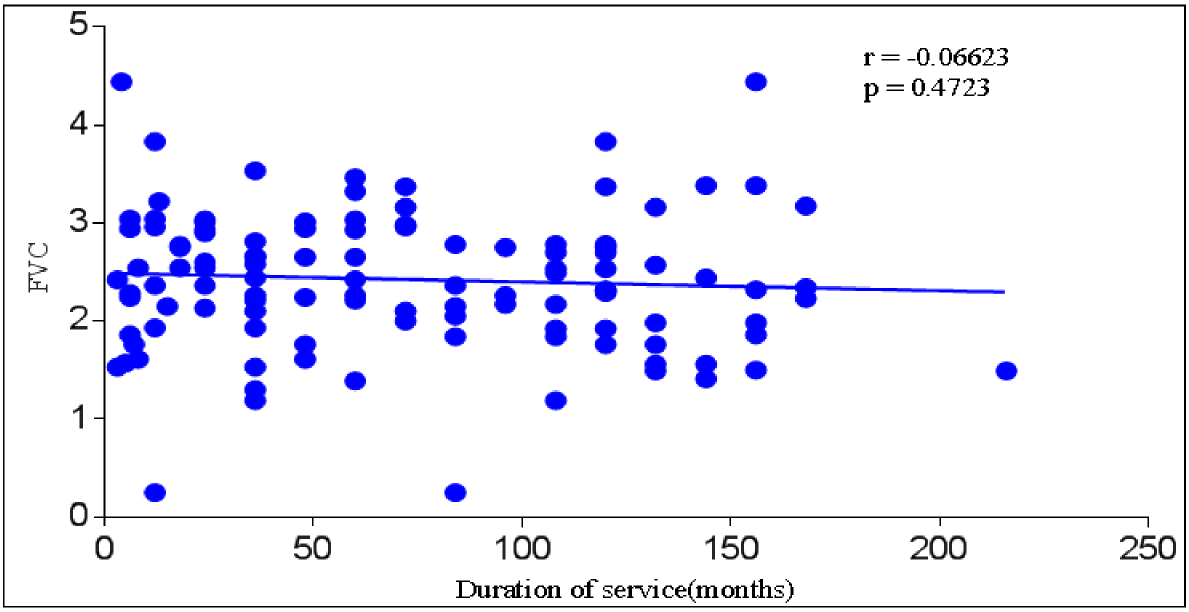

Fig-8: Relationship between duration of service and forced vital capacity in public waste workers

The result for association of duration of service (length of exposure to particulate and gaseous pollutants) with FEV_1 among the test subjects showed a weak negative correlation (r=-0.0891) which was not significant (p = 0.33) (Figure-9).

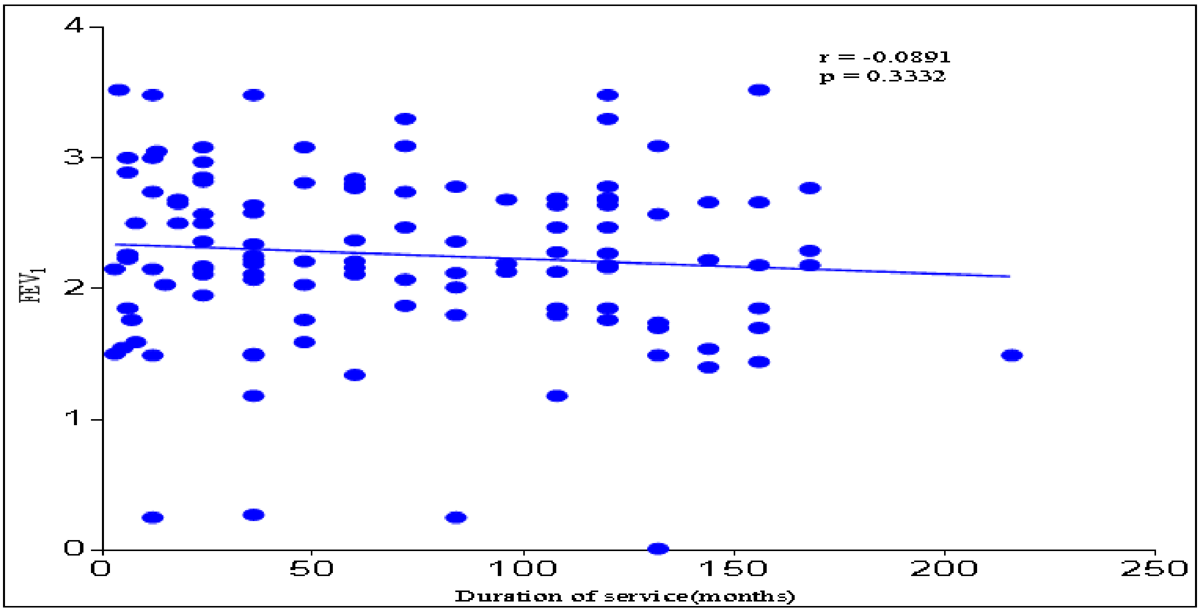

Fig-9: Relationship between duration of service and forced expiratory volume in one second in public waste workers

Figure-10 shows result for the association of duration of service (length of exposure to particulate matter and gaseous pollutants) and FEV_1percent. There was a weak negative correlation (r = -0.04108) which was not significant (p = 0.656).

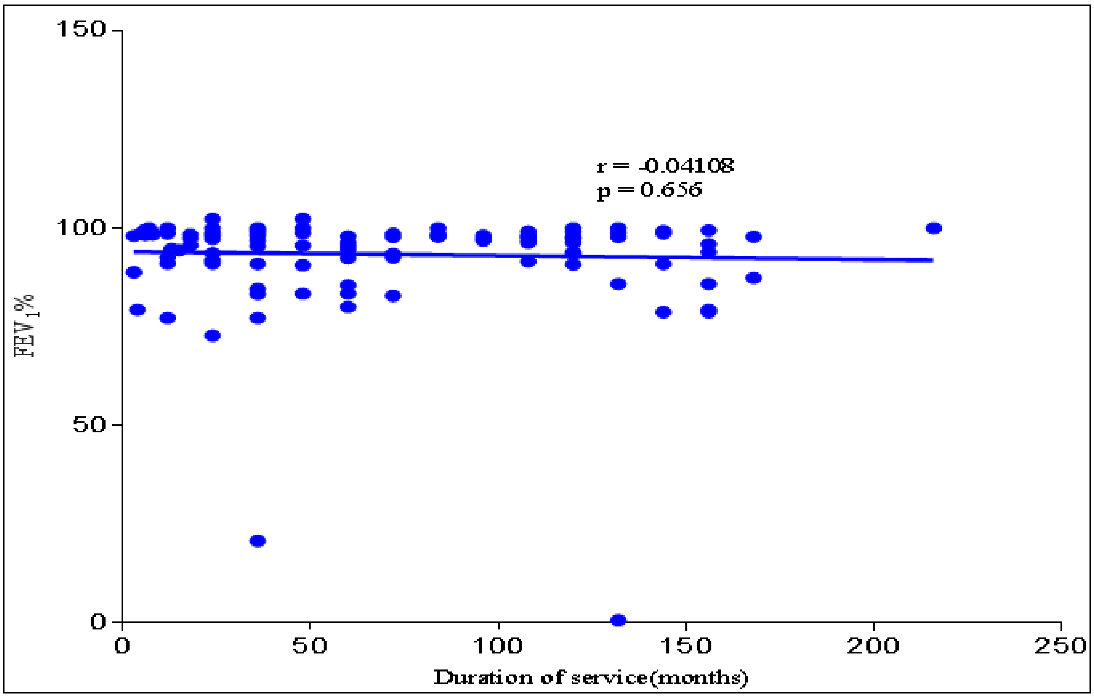

Fig-10: Relationship between duration of service and percentage of forced expiratory volume in one second in public waste workers

Figure-11 shows the result for the relationship between the duration of service (length of exposure to particulate matter and gaseous pollutants) and PEFR. The values for PEFR reduced as the duration of service increased. This showed a weak negative correlation (r=-0.0313) which was not significant (p=0.73).

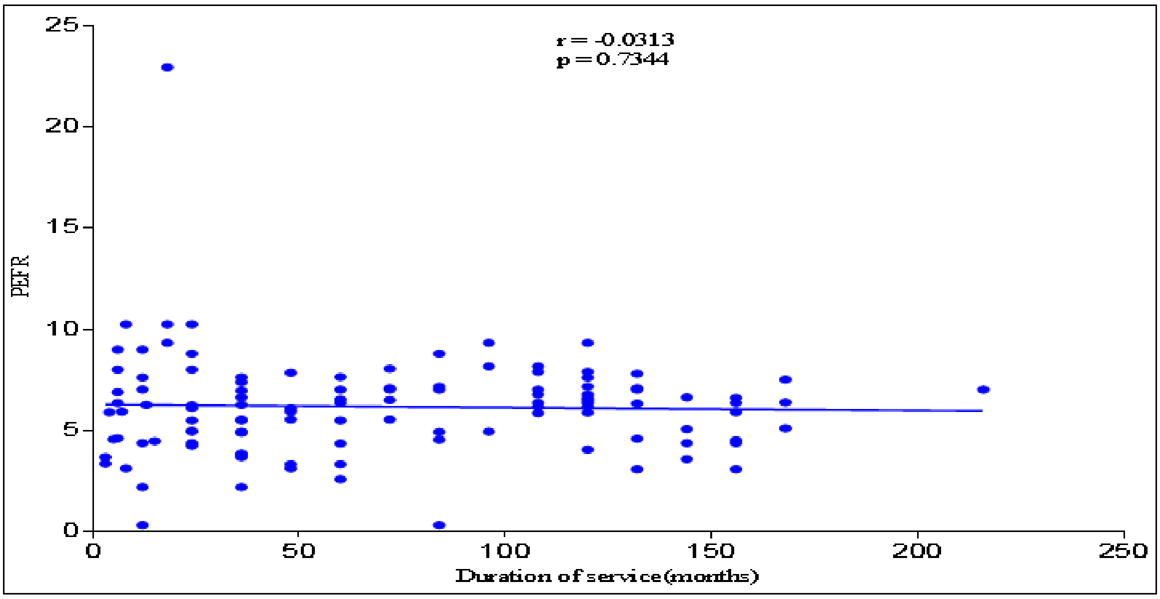

Fig-11: Relationship between duration of service and peak expiratory flow rate in public waste workers

DISCUSSION

Anthropometric values have been reported to affect lung function indices [8, 9]. So, the anthropometric parameters of both control and public waste workers were similar (result not shown) to ensure that any impairment in lung function is attributed solely to the hazards of disposing waste. Occupational environments of public waste workers from documented literature have high amounts of particulate matter and toxic gases which have been implicated in respiratory illnesses [10, 11].

This present study showed that mean values of FVC and FEV_1 were significantly reduced, while FEV_1 percent and PEFR did not change significantly when compared with control values. The above result agrees with a previous work on occupational exposure in municipal solid waste workers in Keratsini, Grece [12]. It also agreed with previous studies on municipal waste workers in terms of results for FEV_1 and FVC, which documented significantly reduced FEV_1 [13] and significantly reduced FVC [14]. In contrast, yet another study by Maduka *et al.*, [15], showed that PEFR was significantly reduced but results for other lung function indices was in line with this present study. FVC and FEV_1 are good indicators for health of the respiratory system [16]. A reduced FVC and FEV_1 but with a normal or raised FEV_1 percent is suggestive of a restrictive ventilatory defect [17, 18] hence public waste workers likely had a restrictive lung condition. In another literature, the above pattern of pulmonary function result reflects failure of an individual to inhale and exhale completely [19]. PEFR is a lung function index used to assess the extent of airway obstruction [20]. The fact that PEFR was not significantly altered in public waste workers buttresses the fact that impairment in public waste workers was solely restrictive.

The relationship between duration of service (length of exposure) and lung function indices showed that the parameters used to assess lung function reduced (not significantly) with increased duration of exposure to hazards associated with waste disposal. This result was in line with a past study which showed a reduction in lung function indices that wasn't significant following increasing duration of exposure to hazards in occupational environment [21]. Long term exposure to particulate matter and toxic gases in documented researches have been associated with impaired lung function [22, 23]. The mean sulphur dioxide (SO_2) concentration in the waste disposal sites was higher than the Federal Ministry of Environment permissible limit. SO_2 at toxic levels as has been documented by literature causes bronchoconstriction, increased upper airway resistance and a progressive decrease in forced respiratory flow [24, 25]. It is probable that the reduced lung function indices is likely as a result of the significant levels of particulate matter and toxic levels of SO_2 found in the refuse disposal sites.

Public waste workers also had a higher prevalence of respiratory symptoms which agrees with a past occupational studies [26, 13]. The low frequency of asthma in both public waste workers and control subjects could be traced to the mean PEFR for both groups which was not significantly different. PEFR from literature can be used to diagnose and monitor asthma progression since it is an index that measures large airway flow [27-29]. A link between particulate matter and occurrence of respiratory symptoms has been documented in literature [30]. particulate matter have been recorded to result in inflammation of lung tissue and mucous membrane (bronchitis) by its action on epithelial cells of the airway and alveolar macrophages which also may lead to airway remodeling [31].

The reason the mean percentage oxygen saturation in public waste workers was not significantly different from control might be because the severity of lung function impairment has not overtly affected gaseous exchange. However, the slight insignificant reduction of O_2 percent saturation in waste exposed workers may mean that with time, the reduction may be significant and dangerous to the exposed workers.

Molecular studies to investigate the mechanism via which exposure to waste alters the cell signaling pathways and affects cell proliferation unfortunately wasn't carried out, a further study in future will explore this. In conclusion, public waste workers in Cross River state, Nigeria are exposed occupationally to high levels of particulate matter and gaseous pollutants which may cause lung function impairment. Their general pattern of lung function impairment is likely restrictive ventilatory impairment and with time their impairment will be worse.

Conflict of interest

We the authors declare no conflict of interest

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