ORIGINAL ARTICLE

Respiratory Symptoms and Pulmonary Function Impairment among Detergent Plant Workers in Jos, Northern Nigeria

Babashani M** *MBBS FWACP*, ****Iliyasu Z** *MBBS MPH FWACP*, ** Ukoli C O**,

**Departments of Medicine and **Community Medicine, Aminu Kano Teaching Hospital and Bayero University Kano, ***Department of Medicine, University of Jos Teaching Hospital*

Abstract

***Background**: The industrial process of detergent production could be deleterious to lung function. This study describes respiratory symptoms and ventilatory function impairment among detergent workers in Jos, Northern Nigeria.*

Methods: Two hundred detergent plant workers and controls were studied for the presence of respiratory symptoms and ventilatory function impairment using the MRC questionnaire and Spirometry.

***Results:** A significantly higher proportion of exposed detergent workers 178 (87.0%) reported respiratory symptoms compared to 52 (26.0%) controls [OR=23; 95%CI=12.9-41.3] (P<0.001). Commonest symptoms include rhinitis (57.5% versus 11.0%) and cough (48.5% versus 15%). Symptoms were most prevalent in the packaging section. FEV_1, FVC and PEFR were significantly reduced among exposed detergent workers. Similarly, the predicted values of PEFR, FVC and FEV_1 were significantly reduced among smokers (P<0.001).*

***Conclusion:** Respiratory symptoms are highly prevalent among detergent workers. This was associated with impaired pulmonary function. Protective equipment and periodic lung function tests could reduce these effects.*

***Key words:** Respiratory symptoms, ventilatory function, detergent workers*

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Introduction

There is a rising prevalence of occupational respiratory diseases in Africa due to expansion of chemical industries and transfer of obsolete and hazardous technology [1]. More than 250 substances found in the workplace could be inhaled leading to a wide spectrum of occupational airway diseases [2,3]. In the industrial process of detergent production, occupational exposure to raw materials and products of several chemical reactions has been associated with bronchoconstriction, cough, excessive mucus production, breathlessness, nasal stuffiness and nocturnal asthma [4,5]. Most occupational respiratory diseases can be diagnosed on the basis of history, physical examination, chest x-ray and pulmonary function tests. The latter provide additional objective parameters and sometimes reveal defects in aspects of lung functions that are inaccessible to ordinary clinical examinations [6].

The most informative tests of ventilatory function are those that involve a forced expiration [7]. This includes the peak expiratory flow rate (PEFR), defined as the fastest flow rate (litres/minute) that can be sustained for 10 milliseconds (ms) during a maximal expiration after full inspiration [8,9]. Other tests are Forced Vital Capacity (FVC), defined as the largest volume (litres) of air that can be delivered by maximal forced exhalation after full inspiration, and Forced Expiratory Volume in one second (FEV_1) representing average flow during first second of the FVC maneuver. The results of the above mentioned lung function tests are standardized by expressing them as percentage of the reference values predicted for age, sex and height. Femi-Pearse and others [9-11] have provided such reference values for the Nigerian adult populations.

Although several studies have been conducted on the effect of occupational exposure to various substances in Nigerian industries [5,12,13], only one study [5] reported on respiratory health of workers in a detergent industry in southern Nigeria. We are not aware of any such study conducted in the northern part of the country. This has necessitated the conduct of this study. The main objective of this study was to determine the prevalence of respiratory symptoms and pulmonary function impairment among workers in the largest detergent plant located in Jos, Northern Nigeria.

Subjects and methods

Location

NASCO detergent factory was established in 1973 and had 236 employees involved in manufacturing of non-enzymatic detergent during the conduct of this study. It

Correspondences to Dr. Musa Babashani, Email: babashanim@yahoo.com +234 8037866247;+234 8053470877

produces 6,000 tonnes of powdered detergent every month. The factory is located in Jos, the capital of Plateau state of Nigeria at an altitude of 4,000 metres above sea level [14]. It operates three 8-hour shifts and is fully automated. There are five sections involved in the chain of production, namely: sulphonation, neutralization, mixing, blowing and packaging. A technical group moves into all sections daily to check and maintain the factory machines. All workers are exposed to Linear Alkyl Benzene Sulphonate (LAS), the active ingredient of detergent in addition to substances peculiar to each section. The technical group had the least exposure period compared to other groups. Only 10% of the workers occasionally wore cotton facemasks as the only respiratory protective device. The pollution monitoring equipment in the factory was non-functional during the study period. Research and Ethical committee of Jos Universty Teaching Hospital approved the study. Similarly, all participants signed an informed consent form before commencement of the study.

Subjects

The subjects of this study were 200 male workers exposed for at least 6 months to raw materials and products of detergent manufacture. The study sample was selected from the different sections of the factory using a stratified sampling technique with proportionate allocation to the different sections. Within each section participants were selected using simple random sampling through use of random number table. Thus, 64, 30, 18, 41, 23 and 24 workers were recruited from the packaging [74], sulphonation [35], neutralization [21], mixing [47], technical [27] and blowing [28] sections respectively. The control group consisted of 200 workers selected using stratified sampling technique from the marketing and trading units. These units are not located near the factory and their workers are not exposed to substances inhaled in the detergent factory. In both the exposed and control groups, subjects who had chest deformity, recent eye, abdominal or thoracic surgery were excluded from this study.

A comparative study of employees exposed to raw materials and products of detergent manufacture and their colleagues working in a separate marketing and trading unit was conducted. The Medical Research Council (MRC) questionnaire on respiratory symptoms[15] modified to include smoking habits was administered on each worker by the authors. Four lung function parameters; Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC), Peaked Expiration Flow Rate (PEFR) and Forced Expiratory Ratio (FER), which is the ratio of FEV_1 / FVC, were determined on all subjects using a computerized flow sensor spirometer (Spirovit SP-110, incorporated into Cardiovit At-10, No. 0124, manufactured by Schiller AG, Alggase 68, Baar Switzerland) and Wright's Peak Flow meter (Clement Clarke International Limited, Re-order No. 310, Essex England). The age, height (in centimeters, Accustat Ross Model, Germany) and weight (in kilograms using bathroom scale, Hanson, China) of the subjects were recorded. Predicted values of FEV_1, FVC, and FER for age and stature were based on formulae recommended by Patrick and Femi Pearse for the African population [16].

Results

Four workers did not participate in the study because they were on annual leave. All the exposed workers were males. The mean ages for the exposed and control groups were 33.58.2 years and 31.87.9 years respectively. This difference was not statistically significant. The duration of exposure ranged from 6 months to 14 years. The mean heights of the workers in the exposed and control groups were 1.630.74 meters and 1.640.83 meters respectively. Similarly, the mean weights of the two groups were 62.79.3 kilograms and 64.59.4 kilograms respectively. These anthropometric measures and proportion of smokers did not differ significantly between the two groups as shown in Table I.

Table I: General characteristics of the subjects (meanSD)

	Exposed	Control	P Value
No. of subjects	200	200	P>0.05
Age (yrs)	33.5±8.2	31.8±7.9	P>0.05
Height (cm)	1.63±0.74	1.64±0.83	P>0.05
Weight (kg)	62.7±9.3	64.5±9.4	P>0.05
Duration of Employment (yrs)	8.3±6.1	6.5±4.7	P>0.05
Proportion of Smokers (%)	15.5	16.0	P>0.05

Respiratory symptoms were present in 178 (87.0%) out of the 200 exposed workers compared to 52 (26.0%) out of the 200 in the control group. This difference was statistically significant [OR=23; 95%CI=12.9-41.3] (^{2}=162.4 df=1 P<0.001). Table II shows that the most prevalent symptoms in the exposed group were; rhinitis 115 (57.5%), cough 97 (48.5%), and breathlessness 89 (44.5%). In contrast, the commonest symptoms in the control group were cough 30 (15.0%), rhinitis 22 (11.0%) and phlegm production 9 (4.55) in that order. Allergy was the least prevalent symptom in the two groups with only 1% and 1.5% having this symptom among the exposed and control groups.

The mean duration of employment of the exposed workers in the detergent factory was 8.36.1 years. The

proportion of workers with respiratory symptoms was highest among those that worked for less than 5 years (52.2%), it decreased to 24.3% and 23.5% among those that worked for 6-10 years and more than 10 years respectively.

The highest prevalence of respiratory symptoms was found among exposed workers in the packaging section of the factory. The proportions that had different symptoms were as follows; cough (37.0%); phlegm production (38.0%); breathlessness (30.3%); tightness in the chest (32.2%); wheezing (44.4%) and rhinitis (30.4%).

Smokers in the exposed and control groups had significantly higher prevalence of respiratory symptoms compared to their non-smoking counterparts. Specifically, cough and phlegm production were present in 60.6% and 30.3% of exposed workers who smoked cigarette. This contrasts with prevalence rates of 48.5% and 25.0 % among exposed non-smokers respectively. Among the controls, 40.3% of smokers had respiratory symptoms compared to 15.0% of non-smokers.

Table II: Prevalence of respiratory symptoms among exposed and control groups

Respiratory Symptoms	Exposed group (n=200) Frequency (%)	Control group (n=200) Frequency (%)
Cough	97 (48.5)	30 (15.0)
Phlegm production	50 (25.0)	9 (4.5)
Breathlessness	89 (44.5)	3 (1.5)
Tightness in the chest	62 (31.0)	4 (2.0)
Wheezing	27 (13.5)	2 (1.0)
Rhinitis	115 (57.5)	22 (11.0)
Allergy	2 (1.0)	3 (1.5)

Table III: Mean values of lung function measurements with percentage predicted values for exposed and control groups (MeanSD)

Index	Exposed		Control	
	Observed	%Predicted	Observed	%Predicted
PEFR(L/min)	509(55)	86.3 (80.0)	552 (51)	93.4(5.6)
FVC (L)	3.00(0.54)	85.8(10.6)	3.45(0.51)	97.8(5.5)
FEV_1(L)	2.48(0.50)	87.5(11.8)	2.84(0.49)	99.6(5.9)

Predicted values for Nigerian men
P<0.001(Significant differences)

Table IV: Mean ventilatory indices expressed as percentage of the predicted value by smoking status (MeanSD)

Index	Exposed		Control	
	Non-Smokers	Smokers	Non-Smokers	Smokers
PEFR	87.2±7.7	81.8±7.9	94.9±4.8	86.9±7.0*
FVC	86.9±10.2	79.9±11.2	98.6±4.5	93.4±7.6*
FEV_1	88.6±11.0	81.7±13.6	100.5±4.4	94.7±9.2*
FEV_1/FVC%	82.8±6.9	83.2±8.0	82.1±3.5	81.4±4.1

Predicted values for Nigerian men
P<0.001(Significant differences)

Table III shows that the mean and percentage predicted values of PEFR, FVC and FEV_1 were significantly lower in the exposed group compared to controls. A similar pattern emerges in Table IV when the participants are categorized by smoking status. Three of the lung function indices (PEFR, FVC and FEV_1) were significantly lower among smokers compared to non-smokers in the two groups. Although FEV_1/FVC% was slightly higher among the exposed group, this difference was not statistically significant. The mean values of lung function tests of workers in the sulphonation section were the lowest compared to other sections.

Nine (33.3%) of the 27 exposed workers who reported wheezing had PEFR and FEV_1 lower than their predicted values with clinical evidence of obstructed airways disease. Similarly, 8 (12.9%) of the 62 exposed workers who reported chest tightness had spirometric and clinical evidence of airways obstruction.

Discussion

This study found a higher prevalence of respiratory symptoms among workers exposed to raw materials and products of detergent manufacture compared to the control group (87% vs 26%). This concurs with observations made by Oleru in a detergent factory located in southern Nigeria [5]. This could be due to the effect of inhalation of substances encountered in the detergent factory. In the present study, rhinitis (57.5%), cough (48.5%) and breathlessness (44.5%) were the commonest symptoms. This also compares with the symptoms reported in the earlier study [5]. They found a combination of cough and phlegm (60.4%) and rhinitis (51.6%) as the commonest respiratory symptoms. These prevalence rates among detergent workers in Nigeria are, however, much higher than those reported by Cullinan et al [17] from a modern detergent factory in the U.K. They [17] found prevalence rates of upper and lower respiratory symptoms to be 19% and 16% respectively. The lower rates from the U.K may reflect the lower levels of industrial pollution, differences in manufacturing technology and the provision of better personal protective facilities. In addition, differences in genetic susceptibility and sensitization levels to various substances inhaled in the detergent factories may contribute to these variations.

There was a decrease in prevalence of cough, phlegm production, breathlessness and wheezing with increased duration of exposure in the first five years,

with a subsequent increase following further exposure. These findings were not consistent with the findings of Oleru [5] who reported a decreased prevalence of respiratory symptoms with increased duration of employment, which he attributed to possible self out selection of workers [18] following intolerance to inhaled substances in the factory.

The prevalence of respiratory symptoms was highest among workers in the packaging section, followed by mixing and the sulphonation sections respectively. The technical and neutralization sections had the lowest prevalence of symptoms. These findings corroborate the findings of Cullinan et al [17] among detergent workers in the U.K. They found a higher prevalence of respiratory symptoms among packaging workers than in the remaining sections of the factory. The higher prevalence of symptoms in packaging and mixing sections was probably due to the dusty nature of these sections compared to others.

In the present study, the mean values of PEFR, FVC and FEV1 were significantly lower for the exposed workers compared to controls, so also were their percentage predicted values. The predicted values for the exposed workers in the present study were higher than those for the same group in the earlier study conducted in southern Nigeria report [5] (average of 86% vs 60%). Similarly, the predicted values for the controls in the present study were higher than those of the control group in the other Nigerian study (FVC;97.8% vs 70.75-74.15% and FEV1(99.6% vs 74.54% to 83.63%). These differences may be attributable to the different types of spirometers used in the two studies. The automated spirometer used in this study may have greater accuracy than the Vitalograph used in the earlier study. This is supported by the report of Anyanwu et al [19], who recorded higher lung function indices with electronic spirometer among healthy young Nigerians compared with earlier reports. In addition, the higher altitude of dwelling in the present study could account for some of the differences. Altitude has been reported to positively affect lung function measurements [20].

In the present study, smokers had significantly lower values of PEFR, FVC and FEV1 than non-smokers in both groups. This concurs with the findings reported among detergent workers in the southern part of Nigeria. They also observed that smokers had lower lung indices than non-smokers. The lower lung function indices among smokers exposed to detergent products may be due to synergistic effect of cigarette smoking and occupational substances in reducing lung function measurements as reported in previous studies [21-23]. The effect of cigarette smoking in reducing lung function of non-exposed individuals has also been established [24,25].

Spirometric obstructive pattern was found in 9% of the exposed workers compared with 6% among the control group. This is comparable with the rates of 7% found in Oleru's study [5] and 8% reported by Cullinan et al [17] in the UK. Restrictive pattern was seen in 43% of exposed workers in the present study compared with much higher values of 66.7% to 100% reported in various subgroups by Oleru [5]. The mean of percentage predicted values of PEFR, FVC and FEV1 for workers in the sulphonation section was lowest compared to the remaining sections. It was highest among the technical section possibly from least exposure. This may be explained by the fact that sulphonation workers were more exposed to sulphur dioxide than other workers. Sulphur dioxide has been shown to cause respiratory irritation, bronchoconstruction and impairment of lung function especially in the presence of airborne particles [26,27].

The effect of exposure to substances in the detergent factory revealed significant reduction in FEV1 and FVC among the exposed workers, while PEFR was reduced albeit not significantly. These findings were consistent with those of Oleru [5]. This demonstrates that exposure to substances found in the detergent factory caused reduction in lung function indices possibly through bronchial hyper-responsiveness and broncho-constriction.

Respiratory symptoms are highly prevalent with associated evidence of ventilatory function impairment among detergent workers in this Nigerian factory. It is recommended that sulphonic acid be purchased instead of producing it through sulphonation in the factory. This will reduce the exposure to toxic gases, particularly sulphur dioxide in the factory. In addition, there is a need to ensure the implementation of effective occupational health measures in similar industries in the developing countries. The measures should include regular maintenance, provision and utilization of personal protective equipment, smoking cessation programmes, pre-employment and periodic medical examination including lung function tests.

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