

## Original Research Article

# Assessment of lung function and pulmonary disorders among women involved in palm kernel oil processing in Cape Coast, Ghana

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## ABSTRACT

**Background:** Does exposure to methods employed during local palm kernel oil processing affect lung function and increase pulmonary disorders in the women processors? Fifty test participants from palm kernel processing sites constantly exposed to processing hazards and fifty unexposed women from the general population in Cape Coast, Ghana were used for the study.

**Methods:** Participants after filling questionnaires were subject to clinical chest examination, anthropometry and spirometry. Data were analyzed descriptively using percentages, means, standard deviation and inferentially using independent sample t-test and chi-square test.

**Results:** Exposed participants complained of respiratory symptoms such as chest pain, phlegm production, burning and tearing of eyes and skin irritations. Chest examination also revealed significant reduced air entry and increase in bronchial and bronchovesicular sounds. Spirometry showed significant decreases in Forced Expiratory Volume in the first second (FEV1) and Forced Vital Capacity (FVC), with increase in restrictive lung disorders in the exposed participants ( $p < 0.05$ ). Chi-square analysis further showed association between length of exposure to emissions from processing and increased lung disorder.

**Conclusions:** Our study shows that the methods employed in palm kernel processing sites coupled with lack of hazardous knowledge and use of protective equipment exposes the women extractors to pollutants which results in increased respiratory symptoms, decreased lung function and significant presence of lung disorders.

**Keywords:** Forced vital capacity, Forced expiration volume, Palm kernel processing, Pulmonary function, Spirometry

## INTRODUCTION

Occupational health refers to the promotion and maintenance of the highest degree of mental, physical and social well-being of workers in all professions and maintaining safe and health working environment is key.<sup>1,2</sup>

The ILO also estimates about 250 million occupational accidents, with asbestos exposure alone, killing 100000 workers annually.<sup>3</sup> Globally, there are about 2 million deaths from work related diseases and 0.3 million occupational injuries annually.<sup>4</sup> With healthcare workers in Africa, Mossburg in 2019 reported that the lifetime prevalence of needlestick injury ranged from 22-95%.<sup>5</sup>

In Latin America and Caribbean, another study estimates that between 27,270 and 73,500 occupational fatal accidents occur each year with high economic costs.<sup>6</sup> The causes of this work-related injuries and deaths include exposure to microbial organisms and toxins, falls, infected fluids, radiation, pollutants, hazardous materials and machinery, amongst others.<sup>7,8</sup> In Ghana, even though small-scale industries such as gold mining, metal and wood works, blacksmithing, palm kernel oil production serve as a major source of income generation, they are not well regulated.<sup>9</sup>

Thus, small-scale work-related injuries are common, and with the exception of gold mining, very few work-related hazards have been researched into. The palm kernel industry exists in five regions of Ghana and fruits of the oil palm tree can be used for palm oil and palm kernel oil production, soap manufacture, palm soup (a major food delicacy) and palm wine production, when it can no longer bear fruits. Despite the potential, Anang and Boadu, (2013) reported that majority of workers involved in palm kernel industry were women, who represent the uneducated and vulnerable, and whose health issues are rarely discussed in the process of earning a living.<sup>10,11</sup>

In addition, the crude processing techniques employed, the harsh working environments and the lack of use of protective equipment exposes these women to enormous amount of dust particles, smoke fumes, heat from the fires, oil splashes and injuries from flying nuts shells, which poses a great danger to their health. Kumah et al, 2014 also reported eye diseases among women engaged in local extraction of palm kernel oil in the Kumasi Metropolis of Ghana due to exposure to hydrogen sulphide, a component of smoke.<sup>12,13</sup>

Prolonged periods of exposure to hazardous agents such as dust and biomass smoke on a regular basis predispose individuals to pulmonary problems such as asthma, obstructive and restrictive lung diseases and silicosis.<sup>14,15</sup> Restrictive and obstructive lung diseases are often diagnosed through clinical examination and spirometry, the latter being a physiological test that measures how an individual inhales or exhales volumes of air as a function of time.<sup>16,17</sup>

Spirometry measurements include Forced Expiratory Volume in the first second (FEV1). The volume of air that can be forced out of the lungs in one second after taking a deep breath, which in healthy individuals is around 75% to 85%. Forced Vital Capacity (FVC) is the amount of air that can be forcibly exhaled with maximum effort from your lungs after taking a deep breath and normal values are greater than 80%. FEV1/FVC ratio is a measurement of the amount of air exhaled in the first second relative to total air exhaled during a maximal exhalation and normal ratio is between 70-80%.<sup>17</sup>

Generally, a lower FEV1 indicates presence of obstructive lung diseases (OLD) and normal to minimally

deceased FEV1 is seen in restrictive lung disease (RLD). Alternatively, a reduced FVC indicates the presence of RLD and normal or reduced FVC is seen in OLD.<sup>18</sup> Obstructive lung disease occurs when inflammation and swelling causes the airways to become narrow or blocked making it difficult to expel air, resulting in a high volume of residual air left in the lungs. Common examples are asthma, bronchiolitis and chronic obstructive pulmonary disease.

In RLD, there is inability to fill the lungs resulting in reduced lung capacity, resulting in shortness of breath, inadequate ventilation and increased difficulty in breathing. It can also be due to stiffness of chest wall, exposure to dust or any particulate matter that fills the alveoli and intrinsic and idiopathic examples include pneumoconiosis and sarcoidosis respectively.<sup>19</sup> In this study, we used female workers involved in small-scale oil palm kernel processing in the Cape Coast metropolis to assess lung function parameters and presence/prevalence of pulmonary function disorders by comparing to a control group of similar demographics who were not associated with palm kernel oil production.

Our findings will help us to ascertain whether (i) palm kernel workers suffer any significant reduction in pulmonary function; (ii) the extent of damage or presence of pulmonary disorders by comparison with standard spirometry measurements and; (iii) any other work-related lung abnormality by assessing statistical differences between the exposed and unexposed participants. Our findings, we believe will steer a change in policy, regulation, production process and increase education so as to provide a safe working environment and reduce occupational hazards for the vulnerable earning a living.

## METHODS

### *Study area and population*

The study was conducted at the Abura palm kernel oil processing site in Cape Coast, Ghana, West Africa. The study population included 50 “exposed” females from the palm kernel oil processing site and 50 “unexposed” females with similar demographics but had no association with palm kernel oil processing. All the female participants consented to be a part of the research.

### *Respiratory questionnaire*

The questionnaire consisted of nine sections which captured demographic status, alcohol and smoking history, experience of respiratory and non-respiratory symptoms and other self-reported health concerns. Other areas captured included knowledge of workplace hazards and use of protective equipment, duration of work exposure, waste management and effects of the workplace hazards.

### Physical examinations

All participants were subject to physicals and clinical examinations to ascertain the shape of the chest wall, the extent of chest expansion, air entry, breath sounds, adventitious sounds and the presence of finger clubbing.

### Anthropometric measurements

Weight and height anthropometry were measured using digital weighing scales (Secarobusta 813) and Stadiometer (Chorder HM-200P) respectively. The weight was recorded in kilograms (kg), height in centimeters (cm) and were together with the participant's age computed into the Spirometer for lung function assessment.

### Spirometry

Participants were oriented on the preconditions required for accuracy of the measurements as recommended.<sup>18</sup> Briefly, they were not to eat large meals or smoke within two hours and abstain from alcohol consumption within four hours to the test. Vigorous exercise was also to be avoided within thirty minutes to taking the test. Participants should also not have undergone any serious medical procedures.

Participants subsequently underwent spirometry to assess their lung function using the Spirometer (spirodoc - Gimaspri 50, srl Medical International Research, Via del Maggiolino, 125 000155 Roma-ITALY), which was calibrated every morning.

The tests were conducted between 10am and 1.00pm with participants seated comfortably and upright with both feet flat on the floor and head slightly elevated. A nose clip was fitted to the nostrils to prevent the escape of air from the nostrils.

The mouthpiece was inserted into their mouth so that at least 2cm of the mouthpiece was inside the mouth ensuring that their lips were completely sealed around it. For FVC and FEV1 measurements, each participant took a deep breath in, as large as possible, and blew out as hard and as fast as possible and kept going until there was no more air left (at least 6 seconds), as recommended.<sup>16</sup>

A total of three readings were taken and if the difference varied by more than 150mL or for any reason the three readings could not be performed, the test was cancelled for a repeat the following day. The best spirometry result after the three tests was recorded as the participants' test result.

### Data processing and analysis

Data from questionnaires were coded into Microsoft Excel and exported into Statistical Product and Service Solution (SPSS) windows version 21 for analysis. A

section of the results was summarized using statistical tables, graphs and charts. Continuous measurements were presented as mean±SD, or medians. Categorical variables were presented as frequencies and percentages. Chi square was employed to assess the association between categorical variables. Comparisons of groups were assessed by the independent sample t-test.

## RESULTS

The demographic information of the 100 female participants captured age, marital status, ethnicity, level of education and religion and is presented in Table 1.

**Table 1: Demographics of study participants.**

Demographic characteristics	Exposed N= 50 (%)	Unexposed N= 50 (%)
<b>Age</b>		
Under 20	0 (0)	0 (0)
20-40	13 (26)	20 (40)
41-60	29 (58)	22 (44)
61+	8 (16)	8 (16)
Total	50 (100)	50 (100)
<b>Marital status</b>		
Married	33 (66)	26 (52)
Single	8 (16)	15 (30)
Widow	4 (8)	5 (10)
Divorced	3 (6)	0 (0)
Co-habiting	2 (4)	4 (8)
Total	50 (100)	50 (100)
<b>Ethnicity</b>		
Akan	11 (22)	43 (86)
Ewe	0 (0)	0 (0)
Ga-Adangbe	13 (26)	1 (2)
Northern tribes	26 (52)	6 (12)
Total	50 (100)	50 (100)
<b>Level of education</b>		
No formal education	21 (42)	4 (8)
Primary	27 (54)	19 (38)
Secondary	2 (4)	18 (36)
Tertiary	0 (0)	9 (18)
Total	50 (100)	50 (100)
<b>Religion</b>		
Christian	39 (78)	40 (80)
Muslim	10 (20)	5 (10)
Traditionalist	1 (2)	5 (10)
Total	50 (100)	50 (100)

The mean ages for the exposed and unexposed controls are 42.72 years and 44.2 years respectively. In both groups, majority of the respondents (>60%) had experienced marriage. Most of the palm kernel workers (78%) were migrants with majority coming from Northern Ghana. With respect to education, 96% of the palm kernel workers had had little (primary/middle) or no education compared to 46% for the control. Most of the participants were Christians - the major religion in Ghana.

### Lifestyle characteristics of study participants

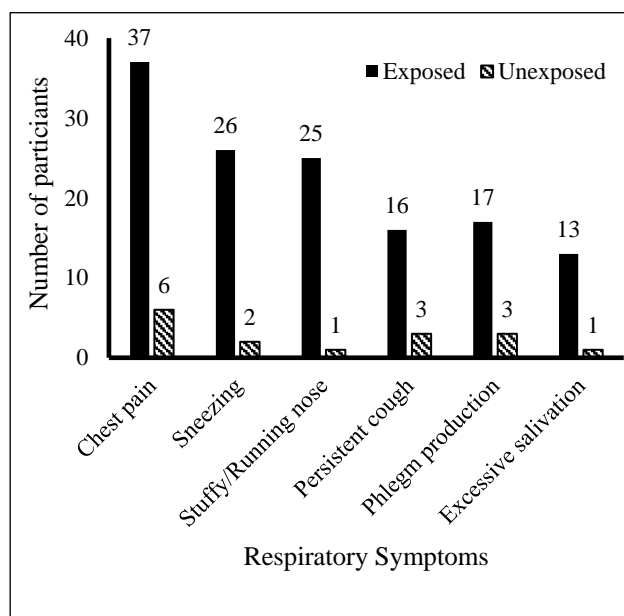
Since smoking and drinking have a confounding effect on spirometry and can affect the results, we assessed smoking and drinking habits of the study participants. All participants interviewed reported to have never smoked.

However, 44% of the exposed group and 26% of the unexposed group drink some alcohol. The drinking patterns were such that it was quite difficult to quantitate effectively. However, averagely we placed the drinking between low-to-moderate. This intake doesn't really affect spirometry readings.<sup>20</sup>

### Health complaints

#### Frequency of respiratory symptoms among study participants

We wanted to know if participants had any symptoms that may denote a compromised respiratory system, so participants were required to select as appropriate from a list in the questionnaire. As shown in Figure 1, there were more incidences of respiratory symptoms experienced by the exposed participants compared to the controls. Most common symptoms were chest pain (74% vs. 12%), sneezing (52% vs. 4%), stuffy/runny nose (50% vs. 2%) and persistent cough (32% vs. 6%).



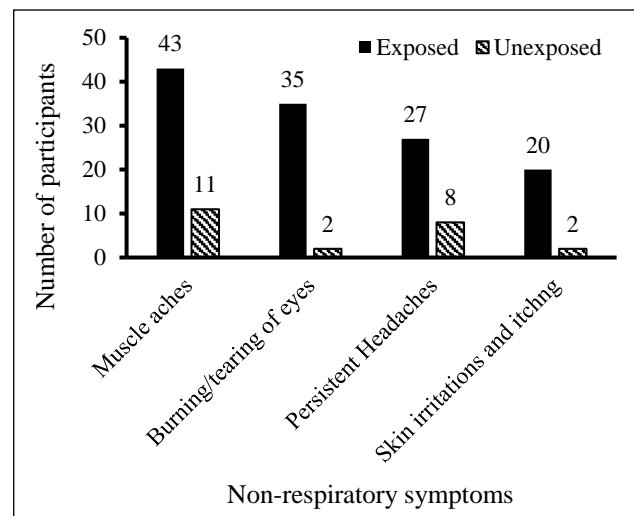
**Figure 1: Prevalence of respiratory symptoms.**

The exposed palm kernel workers significantly reported more respiratory symptoms than the unexposed controls. Most common symptoms expressed were chest pain, stuffy and running nose and persistent cough. Exposed workers also complained about phlegm production and excessive salivation which were not included as options in the questionnaire. Control participants were asked about these last two symptoms and their results are shown. Numbers expressing the various symptoms are indicated on each bar and the differences were significant ( $p < 0.05$ ).

When participants were then asked to record any other symptoms, they believed to be respiratory but were not included in the questionnaire, copious phlegm production which resulted in spitting and excessive salivation were reported more in the exposed workers. The prevalence of most of these symptoms which were significantly higher in the exposed participants may most likely be due to the exposure of the emitted pollutants of dust, smoke or particulate matter during the processing of the palm kernel.

#### Frequency of non-respiratory associated health problems among study participants

We also wanted to ascertain if there were other non-respiratory work-related health problems commonly experienced by the exposed participants. The common non-respiratory symptoms recorded among were muscles aches (86%), burning, reddening, tearing and itching of eyes (70%), persistent headaches (54%) and skin irritations and itching (40%). Once we got these results, the unexposed were asked to respond similarly to these symptoms and the two results were combined. A summary of the findings presented in Figure 2. It shows increased symptoms in the exposed participants.



**Figure 2: Prevalence of non-respiratory symptoms.**

The graph shows that the common non-respiratory symptoms recorded among the exposed group in decreasing order were muscles aches, burning, reddening, tearing and itching of eyes, persistent frequent headaches and skin irritations and itching. Unexposed workers were asked to respond to these symptoms and the combined results showed significant difference between the two groups. Numbers expressing the various symptoms are indicated on each bar ( $p < 0.05$ ).

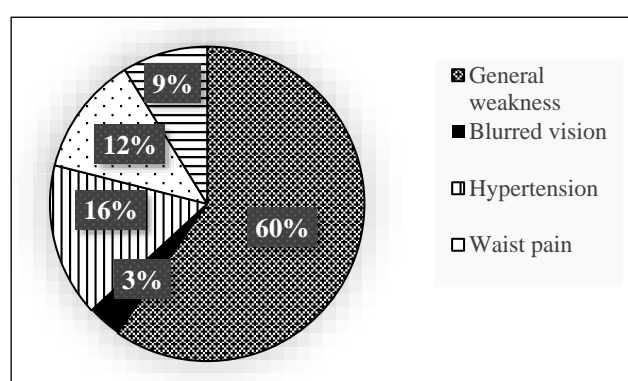
#### Self-reported health concerns among exposed participants

In order not to miss any other health complaints associated with palm kernel processing, the exposed



respondents were given the opportunity to report any health issue they could think of, or any other health problems that may have been diagnosed within a health facility. From the survey, the most common health complaints were: non-specific general weakness at the end of the day (60%), feeling of slowing getting blind/blurred vision (3%) and hypertension (16%).

The claim of hypertension was as a result of irregular checks with a sphygmomanometer and the feeling of blindness were self-diagnosed, so the accuracy of the diagnosis may be in doubt. Two new pain symptoms reported here were waist (12%) and leg pains (9%) which may be due to the nature of the work which involves standing for long hours and lifting of heavy loads. These are summarized in Figure 3.



**Figure 3: Self-reported health concerns of participants.**

The bar chart shows other health related concerns diagnosed or otherwise reported by the exposed participants. Majority complained about general weakness at the end of the day coupled with waist and leg pains. Lifting loads of firewood, long hours of standing and stirring during processing may contribute to these complaints experienced.

### **Knowledge of occupational health and use of protective equipment**

We wanted to know the extent of knowledge with regard to work place hazards and use of protective equipment such as nose and/or face mask, safety boots, safety goggles and protective clothing among the palm kernel processing participants. The study findings showed that none of the exposed participants used any protective equipment. However, with respect to knowledge of the workplace hazards 44.4%, 31.1%, 17.8% and 6.7% mentioned dust, smoke, heat and burns respectively as the main hazards.

Answering the question of whether they believed these hazards were responsible for any of the illnesses experienced, 82% admitted to getting sick from the exposure, 8% believed the sickness may have come from other causes and 10% did not know the cause of their illness. As to whether they have received any form of education or training, 96% of the exposed group had not

received any form of education or training in occupational health and safety and the use of protective equipment.

### **Clinical respiratory examination**

In order to ascertain whether exposure to processing pollutants directly resulted in respiratory abnormalities, clinical examination was carried out for all participants. As shown in Table 2, the exposed group recorded significant differences ( $p < 0.05$ ) in reduced air entry and breath sounds. The differences seen in chest wall deformity, adventitious sound and clubbing of fingers were not significant. The almost equal numbers of both participants (exposed and unexposed) with wheezing and cracking sounds cannot be explained.

**Table 2: Clinical examination of participants.**

Examination result	Exposed	Unexposed	P value
	n=50 (%)	n=50 (%)	
Chest wall deformity	6 (12%)	0	0.083
Air entry (reduced)	27 (54%)	15 (30%)	0.036*
Breath sounds (bronchial and broncho-vesicular)	6 (12%)	2 (4%)	0.044*
Adventitious sounds (wheeze and crackle)	3 (6%)	4 (8%)	0.12

\* $p < 0.05$  = Statistically significant, the unexposed group recorded significantly increased abnormalities in two of the respiratory examinations performed air entry and breath sounds, compared to the control group. Percentages of participants expressing the various symptoms are indicated.

### **Spirometry for FEV1 and FVC**

To determine the presence of lung diseases in exposed participants or whether they have a higher risk of developing a lung condition from the exposure, all participants were subject to spirometry to measure FEV1 and FVC after input of weight, height and age.

With respect to the age, weight and height of the participants, a significant difference was observed with the height, mainly because the unexposed participants were slightly taller. In the exposed participants, the FEV1 and FVC readings ranged from 0.94-2.55 litres (L) with an average of 1.54L, and 1.21-3.76L with an average of 1.99L respectively. On the other hand, FEV1 and FVC readings ranged from 0.93-2.50L with an average of 1.78L and 1.17-3.16L with an average of 2.25L respectively in the unexposed participants. For FEV1/FVC values, the range and averages for the exposed and unexposed participants are 43-97.2 (78.31%) and 60.8-93 (78.85%) respectively. Since there was a reduction in the FEV1 and FVC values in the exposed

participants compared to the unexposed, we proceeded to ascertain if the differences were significant.

Using the student t-test, the difference in FVC and FEV1 values between the exposed and unexposed was significant ( $p < 0.05$ ). From these results which are summarized in Table 3, and within the limits of our statistical analyses, we can conclude that exposure to the pollutants of palm kernel processing without the necessary safety considerations was associated with a significant reduction in FEV1 and FVC values and may indicate a pulmonary disorder.

**Table 3: Spirometry and lung function.**

Parameters	Exposed (Mean, SEM)	Unexposed (Mean, SEM)	P value
Age (years)	47.24 (1.6)	44.8 (1.7)	0.310
Weight (kg)	64.32 (1.7)	69.42 (1.8)	0.083
Height (cm)	153.68 (2.1)	158.58 (1.0)	0.026*
FEV <sub>1</sub> (L)	1.54(0.05)	1.78 (0.05)	0.011*
FVC (L)	1.99 (0.07)	2.25 (0.07)	0.029*
FEV <sub>1</sub> /FVC	78.31 (1.7)	79.88 (1.2)	0.801

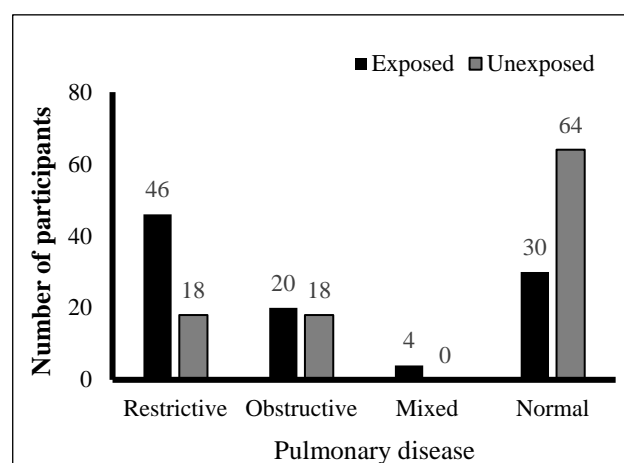
\* $p < 0.05$  significant, SEM: standard error of mean, FEV<sub>1</sub>, FVC and FEV<sub>1</sub>/FVC values for the exposed and unexposed participants. Exposed participants had significantly lower FEV<sub>1</sub> and FVC values than the unexposed, which within the limits of the study could only have resulted from the exposure.

#### Possible diagnosis of pulmonary disorders

We decided to compare the spirometry results from this study with occupational spirometry reference to diagnose possible pulmonary disorders as obstructive, restrictive or mixed. The 3rd National Health and Nutrition Examination Survey (NHANES III) criteria was used for comparison to define airway obstruction.

Using this criterion, Figure 4 shows the FEV<sub>1</sub>/FVC ratio identified seventy percent (70%) of the exposed group with lung disorders (46% - restrictive; 20% obstructive; 4% mixed lung disease) compared to 36% of the

unexposed (18% restrictive and 18% obstructive).<sup>21</sup> Notably, most of the lung disorders were more of the restrictive kind though more tests will be required to confirm this diagnosis. With participants showing obstructive lung disease, there was no significant difference between the two groups and only the exposed group displayed the mixed lung disorder. Not surprisingly, participants exposed to the working hazards had significantly lower normal lung function (30% v 64%) comparatively.



**Figure 4: Lung function disorders among participants.**

Seventy percent (70%) of the exposed group displayed some sort of lung disorder - restrictive pattern (46%), obstructive (20%) and mixed (4%). Majority of control group (64%) had normal spirometry. Chi-square test was used to examine the association between the exposure status and the prevalence of abnormal lung function. The result is presented in Table 4.

#### Association between exposure status and lung function

Chi-square test was used to determine the association between the exposure status and lung function. This was to test whether respondents who were exposed to smoke and dust associated with restrictive, obstructive, normal or mixed lung function. The result shows that there was a significant association between exposure status and lung function (restrictive) ( $X^2 = 12.829$ ,  $p < 0.005$ ) (Table 4).

**Table 4: Chi-square analysis for associations.**

Exposure status	Lung function				$X^2/p$ -value
	Restrictive	Obstructive	Normal	Mixed	
Exposed	23 (46%)	10 (20%)	15 (30%)	2 (4%)	$X^2=12.829$ $P=0.003^*$
Unexposed	9 (18%)	11 (22%)	30 (60%)	0 (0%)	
Total	3 (32%)	21 (21%)	45 (45%)	2 (2%)	

\* $p < 0.05$  = Statistically significant, the chi-square test was significant ( $X^2 = 12.829$ ,  $p < 0.05$ ). From the table, most (60%) of the unexposed respondents have normal lung function as compared to only 30 percent of the exposed respondents. However, 46 percent of the exposed respondents have restrictive lung function as compared to only 18 percent of the unexposed respondents. Moreover, none of the unexposed respondents have mixed lung function as compared to exposed respondents (2%) who have mixed lung function. This shows that most of the respondents who were exposed to dust, heavy smoke, fumes and other aerosol had restrictive lung function and less normal lung function. Using the fixer exact test of the Chi-square analysis, these associations between exposure status and lung function proved to be statistically significant ( $X^2 = 12.829$ ,  $p < 0.005$ ). Thus, exposed participants were more likely to have abnormal lung function compared to unexposed participants and more of the restrictive type.

## DISCUSSION

Palm kernel oil processing is a common small-scale occupation in Ghana and Figure 5 shows the palm kernel processing site at Abura where methods employed are associated with various forms of respiratory health hazards. In this study we determined associated health conditions, lung function status and presence of respiratory disorders in 50 workers involved in palm processing compared to 50 control participants.



**Figure 5: The Abura palm kernel oil processing site.**

The picture shows one of many similar areas within the processing site with several fires for roasting the kernels. Worker use large ladles and sticks to stir during and after the roasting of the kernels and are exposed to constant smoke which may be the cause of the eye problems. The large volume of kernel in the cauldrons makes stirring difficult hence the general pains and weakness. As seen, large aluminum pans, barrels, palm kernel husks, the unevenness of the site, amongst others makes it an unsafe environment for processing.

The all-female workers here conform with other studies in Ghana and Nigeria and the mean age of  $42.72 \pm 11.34$  years is also quite similar to other studies, where over 40% of the workers were aged between 35-54 years.<sup>10-13,22</sup> Most participants being Christians and married is quite normal in Ghana with a high Christian population and average marriage age of 24 years.<sup>23</sup> More exposed workers were from northern Ghana (52%), supporting migration to the south in search of menial jobs.<sup>23</sup> Majority of the exposed participants (60%) have little or no education is in line with another report and the normal trend worldwide where the least educated correlates with low socioeconomic status and low paying tedious jobs.<sup>11</sup>

The study findings indicated non-smoking participants so there was no need to make adjustments as smoking reduces lung function.<sup>24</sup> Though moderate alcohol intake was reported, the effects of alcohol on respiratory function is still not clearly classified, and without quantification, we dropped it since moderate alcohol intake does not have significant effect on lung function.<sup>20</sup>

There generally high prevalence of respiratory symptoms such as chest pains, sneezing, persistent coughing, etc.

among the exposed participants is most likely due to exposure to mainly smoke and dust emitted during the palm kernel processing. Similarly, other exposed workers such as restaurant workers in Thailand and women involved in community cooking using firewood in Burkina Faso reported similar symptoms and the severity was directly proportional to the extent of exposure.<sup>25,26</sup>

Again, our exposed participants reported phlegm production and excessive salivation and same were also mentioned by the restaurant and community cooking workers above.<sup>25,26</sup> Lastly, the exposed participants mentioned work-related conditions such as burning and tearing of eyes, skin irritations, waist pains and feeling of slowly getting blind. Not surprising, the workers above, and others exposed to smoke and dust in Malawi, Norway and Nepal also reported similar.<sup>25-29</sup>

The feeling of getting blind is note-worthy because another palm kernel study in Kumasi, Ghana reported cataracts, pterygium and pingueculum in 150 respondents.<sup>13</sup> In all cases in our study, there were significant differences in symptoms between the exposed and unexposed participants. Majority (90%) of exposed workers were able to identify work-related hazards such as dust (43.3%), smoke (34%) and heat (17.5%). This awareness was attributed to having seen or experienced a work-related accident, similar to findings of other palm kernel workers.<sup>30</sup>

None of the exposed participants used any form of protective equipment even though they knew its usefulness. The main reason was lack of purchasing power which is common in developing countries as other studies in India and Nigeria show.<sup>31,32</sup>

Due to breathing in of fine particulate matter in the continuous visible smoke and dust produced during oil processing, we anticipated that exposed workers will have respiratory problems.

Clinical examination revealed significant reduction in air entry and increased breath sounds probably due to fluid in the lungs. Though there was increased chest wall deformity and finger clubbing, which are indicators of lung disease or compromised respiratory system in the exposed participants, the differences compared with the unexposed participants was not significant. To confirm the presence or absence of obstructive, restrictive and mixed lung disease, we assessed FEV<sub>1</sub>, FVC and FEV<sub>1</sub>/FVC using spirometry. The average values for FEV<sub>1</sub>, FVC and FEV<sub>1</sub>/FVC determined are 1.54L, 1.99L and 78.3% respectively in the exposed participants. Another study conducted in Ghana in a mining community reported measured values of 2.31L, 2.461L and 91.65% respectively for FEV<sub>1</sub>, FVC and FEV<sub>1</sub>/FVC compared to the predicted values of 2.84L, 3.30L and 82.14%, showing a decrease, probably due to the exposure to mining pollutants.<sup>33</sup> Three other studies in females in Nigeria, Benin and Rwanda, (sub-Saharan

countries) reported 2.24L, 2.52L, 89.5%; 2.05L, 2.71, 75.6% and 2.4L, 2.78L 86.3% respectively<sup>34-36</sup> and average values for black females in Brazil<sup>37</sup> and USA<sup>38</sup> are shown in Supplementary Table 233-38, where reference values differ per country. The variation is due to the influence of parameters such as age, height, weight,

ethnic origin, standard of living and lifestyle choices, which is different for every country. It would have therefore been worthwhile to have comparative figures for women in Ghana, but there is paucity of data and values reported<sup>33</sup> are majority men, as they are involved in mining.

**Table 5: Spirometry values for other sub-Saharan and American countries.**

	(33) Test	(33) Predicted	(34)	(35)	(36)	(37)	(38)
<b>FEV1</b>	2.3L	2.84L	2.24L	2.05L	2.4L	2.55L	2.46L
<b>FVC</b>	2.46L	3.30L	2.52L	2.71L	2.78L	3.10L	2.53L
<b>FEV1/FVC</b>	91.60%	82.10%	89.50%	86.20%	86.20%	82%	89%

Other FEV1, FVC and FEV1/FVC values reported for Ghana, some sub-Saharan countries, Brazil and the USA. Reference 33 are test and predicted values for a study conducted in a mining town in Ghana.

The 3rd National Health and Nutrition Examination Survey (NHANES III) reference values is used as standard for comparison with the spirometry results. Generally, reduced FEV1, normal or reduced FVC and reduced FEV1/FVC ratio is indicative of OLD, especially reduced FEV1/FVC ratio.<sup>22</sup> Alternatively, reduced to normal FEV1, reduced FVC and normal to high FEV1/FVC ratio is indicative of RLD.<sup>18</sup> This study found a significant reduction in FEV1, FVC and FEV1 /FVC ratio for the exposed group compared to the unexposed (Table 3).

Using the NHANES criterion, we determined that 66% of the exposed participants had some form of lung disorder (46% restrictive and 20% obstructive) and 64% of unexposed had normal lung function. T-test performed showed statistically significant difference between exposure and the prevalence of abnormal lung function ( $t = -3.064$ ,  $p < 0.05$ ). This means that exposed participants were more likely to have abnormal lung function as compared to unexposed participants. A similar finding of increased restrictive lung function was also observed in palm kernel workers in Malaysia.<sup>39</sup>

Finally, using Chi-square test, the study also confirmed that exposure to heavy smoke, fumes, dust and other aerosol were associated with restrictive lung function (Table 4). The increased lung disorders reported here is not conclusive of the presence of any lung pathology since spirometry alone cannot be used for accurate diagnosis of RLD though it can be used to rule out OLD. Spirometry test repetitions over time and FEV1/FEV6 ratio determinations are now being proposed as markers better for diagnosis and should be included in any further studies.<sup>40</sup>

### Limitations

The study had some limitations. Few test participants were used, but within the locality, that was the most significant sample size available. Control participants were selected because they were not in the palm kernel

industry and could have had respiratory problems from other sources, but this had no influence on our exposed results.

### CONCLUSION

This study has shown that even though palm kernel processing provides income for females, the monetary benefits may be outweighed by associated respiratory disorders, compromised lung function eye and skin irritations and general weakness. There was a significant reduction in all the lung function parameters measured - FEV1, FVC and FEV1/FVC ratio of the exposed group comparatively, thereby calling for larger study and more confirmatory tests. Such study should include other parameters such as Vital Capacity (VC), Inspiratory Vital Capacity (IVC) Peak Expiratory Flow (PEF), Forced Expiratory Volume in the third and sixth second (FEV3; FEV6), amongst others for better diagnosis.

We will also recommend to policy makers in Ghana to expedite the Occupational Health Bill to pass the health and safety policies in order to ensure safe practices at workplace, environmental considerations and access to occupational health care. We will also entreat the municipal to educate the women on fire safety and also make the place decent for working.

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