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ORIGINAL RESEARCH

Respiratory Symptoms and Lung Function Indices of Grilled Meat ("Suya") Sellers in Calabar, Nigeria

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Abstract

Background: The grilled meat (*Suya*) business exposes its employees to wood smoke and cooking oil fumes, which can cause impaired lung function.
Objective: To compare the prevalence of respiratory and non-respiratory symptoms and lung function indices of *suya* meat sellers with those of control subjects in Calabar, Nigeria.
Methods: Cluster sampling was used. The population consisted of 83 male grilled meat sellers and 83 male control subjects aged 19 – 40. A self-structured questionnaire was used to obtain their biodata and information on respiratory and non-respiratory symptoms. After that, forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV_1/FVC and peak expiratory flow rate (PEFR) were measured and used as indices of pulmonary function.
Results: Age, anthropometric parameters (weight, height and chest circumference), pulse rate, and oxygen saturation were not significantly different between the two groups. FVC, FEV_1, FEV_1/FVC and PEFR were significantly lower (p = 0.042, <0.001, <0.001, and <0.001, respectively) in the test group compared with the control and correlated negatively (p<0.001, <0.001, 0.004 and <0.001, respectively) with the duration of work of the test subjects. About 74% and 60.24% of the test subjects reported chest pain and sneezing, against only 28.91% and 19.28% of the control subjects who reported having these respiratory symptoms. Many test subjects had headaches (84.34%) and waist pain (74.70%), while only a few control subjects had these symptoms (14.46% and 9.64%, respectively).
Conclusion: Chronic exposure to wood smoke and cooking oil fumes from grilled meat (*suya*) preparation impairs lung function, which worsens with increasing duration of exposure.

Keywords: Calabar, Cooking Oil Fumes, Grilled meat, Lung function, PEFR, Wood smoke.

Introduction

The exposure of the human body to toxic domestic and industrial air pollutants is common in many societies. Air pollutants from the combination of Wood Smoke and Cooking Oil Fumes (WSCOFumes) are associated with various health anomalies. The mixture of WSCOFumes contains toxicants that encounter the normal air and eventually enter the human body via the respiratory tract during inhalation. Globally, it has been reported that air pollution hazards account for over 6% of all deaths. [1] About 7 million premature deaths occur every year from the combined effects of ambient and household air pollution basically because of increased mortality from heart disease, lung cancer, chronic obstructive pulmonary disease and acute respiratory infections. [2] In Africa, Nigeria has the highest fatalities caused by air pollution. In the Niger Delta region of Southern Nigeria, air pollutants massively cause respiratory diseases and deaths. [3] Studies have shown WSCOFumes to contain toxic substances, including carcinogens such as polycyclic aromatic hydrocarbons and aldehydes. [4] Other substances reported to be contained in wood smoke include phenols, benzopyrenes and oxides of Sulphur and Nitrogen. [5] Evidence suggests that persons whose occupations expose them to wood smoke are likely to suffer chronic obstructive pulmonary disease.[6] The lungs provide the most common portal of entry into the body of hazardous substances in the air and may, themselves, be affected. Therefore, the normal functioning of the lungs is easily impaired by pollutants, mostly smoke, dust and other harmful gases. Even short-term exposure to wood smoke has resulted in an elevated risk of respiratory symptoms and reduced lung function.[7]

In Nigeria, there are persons whose occupation involves the making and selling of grilled meat called "Suya". *The suya* meat business is a lucrative business carried out in all the states in Nigeria, but it is the most common among the Hausas in Northern Nigeria. *Suya* meat is prepared by salting fresh meat and grilling it with heat from burning wood. The meat is turned at intervals, and cooking oil is added until it is done.[8] Therefore, the health of *suya* meat sellers is at risk due to exposure to toxic compounds from WSCOFumes. In Ile-Ife and Bogota communities in Nigeria, women exposed to wood smoke were reported to suffer from obstructive airway disease.[9]

In Calabar, Cross River State, Nigeria, there is a large area known as Suya Arcade, where the *suya* meat business is carried out on a large scale for commercial purposes. Since WSCOFumes are toxic to health, one would not doubt the possibility of pulmonary diseases among the *suya* meat sellers in Calabar. Although some studies have been carried out to investigate respiratory symptoms and lung function indices in some populations in Nigeria,[10,11] there is a paucity of information on lung function indices of *suya* meat sellers in Nigeria. Therefore, the present study investigated lung function indices and respiratory and non-respiratory symptoms in grilled meat (*suya*) sellers in Calabar, Nigeria. Also, the relationship between the meat sellers' work duration and their lung function indices was assessed. The ambient air quality of the Suya Arcade, control environments and some *suya*-making areas was also evaluated.

Methods

Study setting

The study was carried out in Calabar, Nigeria. Calabar is the capital city of Cross River State in Nigeria between February and March 2020. Cross River State is bounded by the Republic of Cameroun in the East, Benue State in the North, Ebonyi State in the Northwest, Abia State in the West, Akwa Ibom State in the Southwest and the

Atlantic Ocean in the South. The state lies between latitude $5^0$32′ and $4^0$27′ North and longitude $7^0$50′ and $9^0$50' East of the Greenwich Meridian. It has a land area of 20,156 square kilometres.[12]

Study design

The design was a comparative, cross-sectional study consisting of two groups: a test group and a control group. The subjects in each group were males because Nigeria's meat grilling (*suya*) business is male-dominated. A cluster sampling technique was used to obtain data from the subjects in different locations in Calabar, Nigeria. The control group consisted of 83 males, including people in business, students, and civil servants, who had neither worked as *suya* meat sellers nor were exposed to wood smoke and/or cooking oil fumes. The test group consisted of 83 male *suya* sellers working at the Suya Arcade and some other areas in Calabar. Both groups of subjects were age- and weight-matched.

Exclusion criteria

Subjects who were smokers, asthmatic and/or undergoing treatment for tuberculosis were excluded from the study.

The control subjects consisted of non-smokers, people not exposed to wood smoke and cooking oil fumes, and people living where *suya* is not processed. The test subjects included non-smokers who processed and sold grilled (*suya*) meat.

Materials

A structured questionnaire, which was validated by a Test and Measurement expert in the University of Calabar, tape measure, Vitalograph Spirometer (Vitalograph limited Buckingham, England) for measuring lung function indices, bathroom weighing scale for measurement of the weight of subjects, a pulse oximeter (Santa Medicals, USA) for measuring oxygen saturation level (SPO_2), Mini-Wright peak flow meter (AIRMED, Clement Clarke International Ltd., England) for measurement of peak expiratory flow rate and a stadiometer for measurement of height of subjects.

Study procedure

A structured questionnaire was administered to each group and explained to the understanding of the subjects. The questionnaire was also used to evaluate the subjects for respiratory and non-respiratory symptoms. Eighty-three subjects were chosen for each group to have an appreciable sample size. Anthropometric parameters were obtained, and lung function indices were evaluated by spirometry.

Measurement of anthropometric parameters

The weight of the subjects was measured using a weighing scale. Their chest circumference was measured using a flexible tape, while their height was measured using a stadiometer.

Evaluation of respiratory and non-respiratory symptoms

The questionnaire was used to collect information on the respiratory and non-respiratory symptoms of the study participants. The respiratory symptoms of interest were wheezing, sneezing, catarrh, chest pain, and dyspnea, while the non-respiratory symptoms were headache, waist pain, body pain and dizziness.

Measurement of lung function indices

A Vitalograph Spirometer (Vitalograph Limited Buckingham, England) was used to measure the lung function indices of the study subjects. The lung function indices were measured with each subject in a standing position. Each subject was asked to fix their mouth firmly to the mouthpiece of the spirometer and inspire maximally. Thereafter, they were asked to expire forcefully through the mouth into the spirometer. The mouthpiece of the spirometer was sterilised using cotton wool and methylated spirit before and after each test. The test was done three times, and the best among the three readings was taken as the final. Standardised instructions were given according to the criteria of the American Thoracic Society.[13] The lung function indices assessed included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC, and peak expiratory flow rate (PEFR).

Measurement of arterial oxygen saturation and pulse rate

A finger pulse oximeter (Santa Medicals, USA) was used for the measurement of arterial oxygen saturation, while the pulse rate was measured using a Mini-Wright peak flow meter (AIRMED, Clement Clarke International Ltd., England).

Ambient air quality assessment

Different sampling points that correctly represented the study site and other pollutant gases were assayed to determine their concentration in the ambient air. The following were the pollutant gases whose concentrations were measured: Sulphur (IV) oxide (SO_2) and Nitrogen (IV) oxide (NO_2). The concentration of suspended particulate matter and the magnitude of electromagnetic radiation were determined using environmental gas monitors and detectors. The concentration of pollutant gases was measured in parts per million (ppm). In contrast, suspended particulate matter was measured in micrograms per cubic meter ($\mu g/m^3$) and the electromagnetic radiation level in counts per minute (cpm). ALTAIR® 4X Multi Gas Detector (Johnson controls, UK) was used to automatically detect the concentrations of SO_2 and NO_2 in the study areas. In contrast, the average concentrations of delicate Suspended Particulate Matter, which are very hazardous to human health, were obtained at the sampling areas using the 2.5 µm and 10µm dust particle measuring device known as the PCE-RCM 10 (PCE Instruments UK Ltd).

Statistical analyses

The data was summarised and expressed as percentages/proportions for categorical variables and mean ± standard deviation (SD) for continuous variables. The Statistical Package for Social Sciences (SPSS) version 20 was used for the analysis. Students t-tests were performed to compare the means of the control and test groups for the continuous variables. The association between *suya* meat sellers' work duration and their lung function indices was performed using Pearson's correlation coefficient. The statistical significance level was set at p-values of < 0.05.

Ethical approval

Ethical approval for the study was obtained from the Ministry of Health, Calabar, Cross River State, Nigeria. Each subject signed a written informed consent form. All ethical principles, including respect for subjects, independence, and confidentiality, were followed.

Results

Prevalence of respiratory symptoms among study participants

Table I shows the prevalence of respiratory symptoms as self-reported by the study subjects. The most frequently reported symptom was chest pain in 74.7% (62/83) and 28.91% (24/83) of the control group. About 60% (50/83) of the test subjects reported frequent/continuous sneezing, which is much higher than the 19.28 % (16/83) of the control subjects that reported the same. Catarrh was reported in 50.6% (42/83) of the test group, thrice higher than the 14.46% (12/83) of the control subjects. Wheezing and dyspnea were the least occurring respiratory symptoms common to both groups of subjects, but they were still more frequent in the test subjects. For the test subjects, 44.58% (37/83) and 36.14% (30/83) reported wheezing and dyspnea, respectively, while only 9.64% (8/83) of the control group reported the same symptoms.

Table I: Respiratory symptoms in test and subjects

Symptoms	*Control subjects (n = 83)*		*Test subjects (n = 83)*	
	Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**
Chest pain	24	28.91	62	74.70
Sneezing	16	19.28	50	60.24
Catarrh	12	14.46	42	50.60
Wheezing	8	9.64	37	44.58
Dyspnea	8	9.64	30	36.14

Prevalence of non-respiratory symptoms among study participants

Table II shows the non-respiratory symptoms recorded among the study participants. The commonest non-respiratory symptom was headache, recorded in 84.34% (70/83) of the test subjects and 14.46% (12/83) of the control subjects. Waist pain had the second highest occurrence. It occurred in 74.70% (62/83) of the test subjects and 9.64% (8/83) of the control subjects. The test and control subjects reported body pain in 49.4% (41/83) and 9.64% (8/83) of cases, respectively. Dizziness was the least occurring non-respiratory symptom. It occurred in 39.76% (33/83) of the test subjects but only 4.82% (4/83) of the control subjects.

Table II: Non-respiratory symptoms in control and test subjects

Symptoms	*Control subjects (n = 83)*		*Test subjects (n = 83)*	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Headache	12	14.46	70	84.34
Waist pain	8	9.64	62	74.70
Body pain	8	9.64	41	49.40
Dizziness	4	4.82	33	39.76

Comparison of age and anthropometric parameters between control and test groups

Figure 1 shows the mean age and anthropometric parameters of the study participants. The age, body weight, height, and chest circumference of the test group showed no significant difference compared with the control group.

Comparison of lung function indices between control and test groups

Figure 2 shows that the FVC, FEV_1, FEV_1/FVC and PEFR were significantly ($p = 0.042$, <0.001, <0.001 and <0.001, respectively) lower in the test group compared with the control group.

Correlation/association between duration of work and lung function indices

Figure 3 shows the correlation analyses between the duration of work and lung function indices of *Suya* meat sellers. The correlation analyses between the duration of work and FVC ($r = -.737$; $p<0.001$) and FEV_1 ($r = -.787$; $p<0.001$) were negative and significant. The FEV_1/FVC and PEFR were also negatively correlated $r = -0.310$ ($p = 0.004$) and -0.587 ($p<0.001$) respectively with duration of work.

Comparison of oxygen saturation between control and test groups

Figure 4 shows the mean oxygen saturation levels of the study participants, which was not significantly different between the two groups.

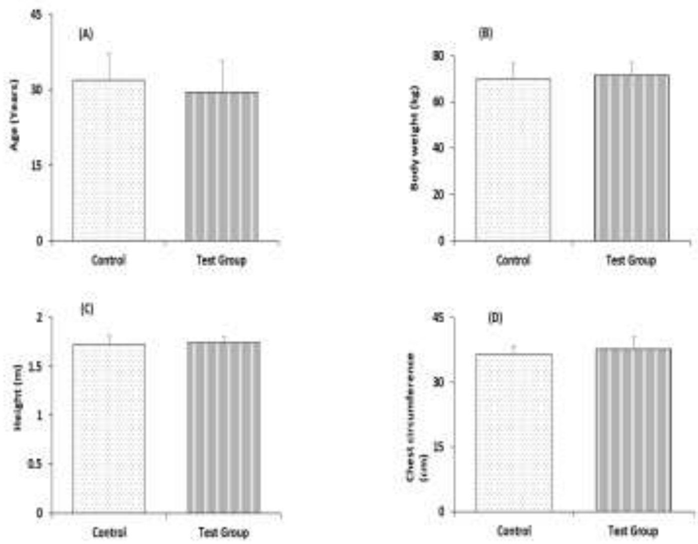

Figure 1: Age and anthropometric parameters between control and test subjects. (A) Age, (B) Body weight, (C) Height, and (D) Chest circumference. [Values are mean ± SD, n = 83. No significant difference between groups].

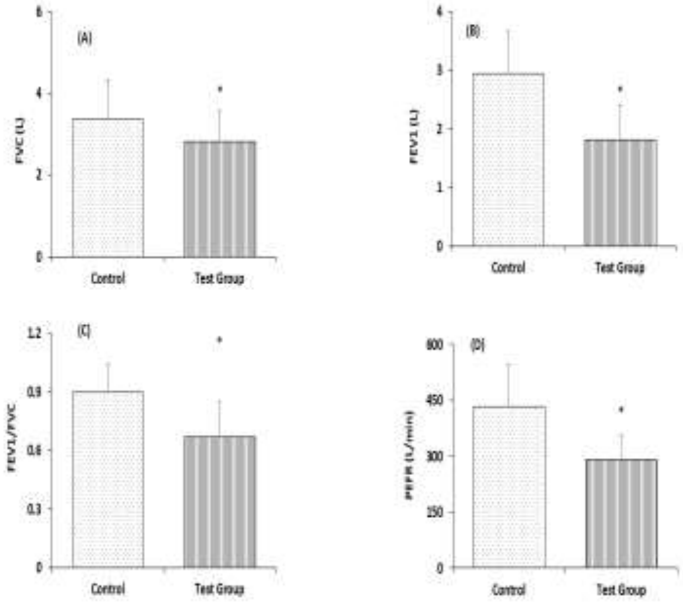

Figure 2: Lung function indices between control and test subjects. (A) FVC, (B) FEV1, (C) FEV1/FVC, and (D) PEFR. [Values are mean ± SD, n = 83. *$p < 0.05$ vs control].

Comparison of pulse rate between control and test groups

Figure 5 shows the pulse rate of the study participants, which was also not significantly different between the control and test groups.

Comparison of ambient air between control and test areas

Figure 6 shows the ambient air quality assessment in the control and test group areas.

The concentrations of particulate matter 10 (PM_{10}) and particulate matter 2.5 ($PM_{2.5}$) (µg/m³) of the test areas were significantly ($p = 0.0003$ and 0.036, respectively) higher than in the control areas. The concentrations of SO_2 and NO_2 were also considerably ($P < 0.05$) higher in the test areas compared with the control areas. There was, however, no significant difference in the radiation level between the control and test areas.

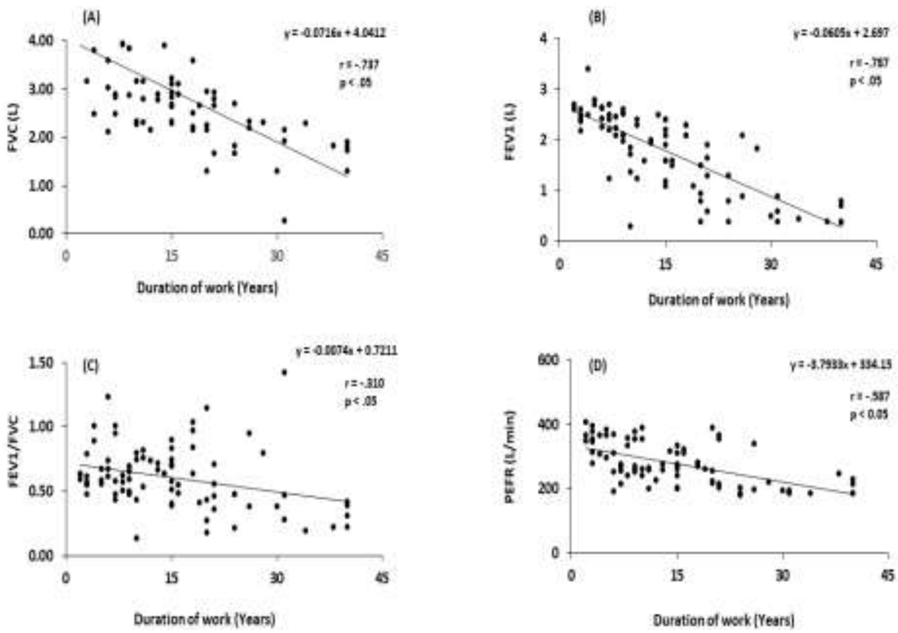

Figure 3: Correlation analyses between duration of work and (A) FVC, (B) FEVI, (C) FEV1/FVC and (D) PEFR values. The equation on each chart represents an equation of a straight line where the coefficient of x is the gradient, and the constant is the intercept on the y-axis. Pearson correlation coefficient is denoted as "r".

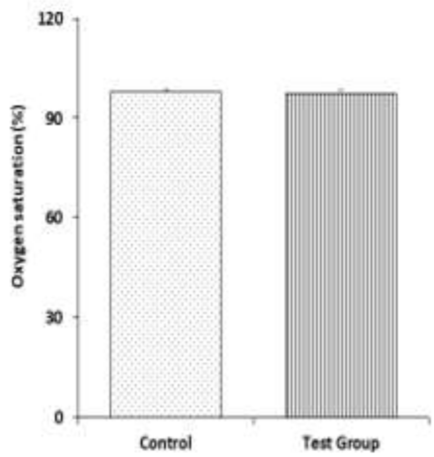

Figure 4: Oxygen saturation level between control and test subjects. [Values are mean ± SD, n = 83. No significant difference between groups].

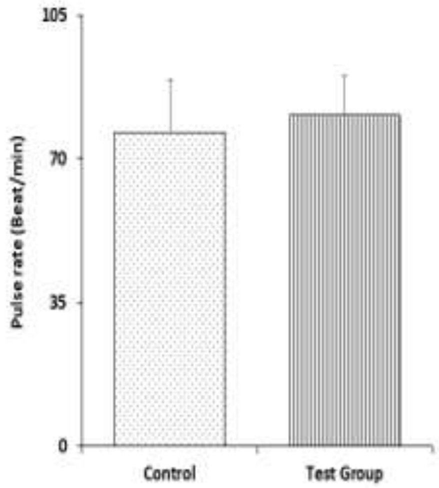

Figure 5: Pulse rate between control and test subjects. [Values are mean ± SD, n = 83; No significant difference between groups]

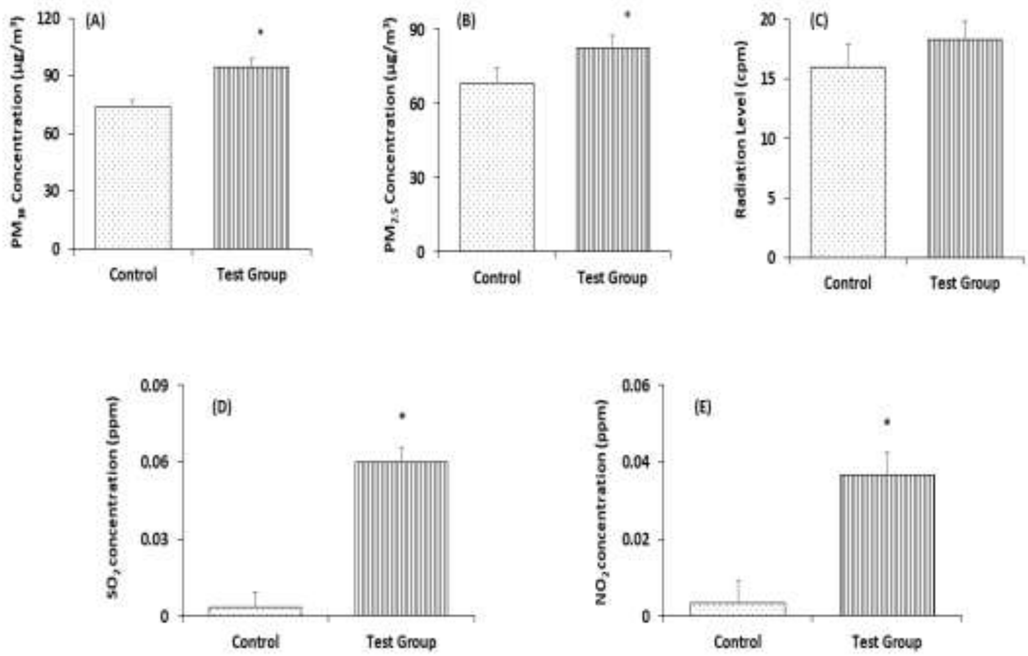

Figure 6: Ambient air quality assessment between control and test areas. (A) PM_{10} concentration, (B) $PM_{2.5}$ concentration, (C) Radiation level, (D) SO_2 concentration, and (E) NO_2 concentration [Values are mean ± SD, n = 83. $^*p < 0.05$ vs control].

Discussion

This study investigated the respiratory and non-respiratory symptoms and lung function indices among *suya* meat sellers in Calabar, Nigeria. The results showed that respiratory symptoms such as chest pain, sneezing, catarrh, wheezing and dyspnea were more frequent among the test subjects than the control subjects. These findings align with a previous study where an increase in respiratory symptoms, mostly coughs and wheezing, was reported among Northern Nigerians exposed to wood smoke and oil fumes.[14]

This suggests that the high prevalence of respiratory symptoms among the *suya* meat sellers is due to their exposure to WSCOFumes and not because of cigarette smoking and/or previous ailments like asthma. Moreover, there are well-established facts that smoke contains thousands of toxic chemicals, including nitrogen dioxide, particulate matters, formaldehyde and acrolein, which are respiratory irritants.[15] Exposure to these pollutants is known to cause damage to the respiratory tract, resulting in cough and other respiratory symptoms. [16,17] The high prevalence of respiratory symptoms among the test subjects in this study may also be attributed to the long duration of work. The mechanism of action may be airway inflammation and subsequent development of bronchial hypersensitivity.[18] Furthermore, mechanical factors, including muscle activity associated with pulmonary hyperinflation, bronchial hyperresponsiveness and cognitive factors, have been proposed to influence the perception of dyspnea.[19] Eosinophilic airway inflammation has also been proposed as a determinant of dyspnea via mechanisms affecting either the mechanical pathways that control dyspnea[20] or the afferent nerves involved in the perception of dyspnea.[21]

The non-respiratory symptoms such as headaches, waist pain, body pain, and dizziness were more frequent in the test group. The cause of headache amongst the *suya* meat sellers could be attributed to the continuous inhalation of the incomplete combustible products of the wood smoke. One of the products of wood smoke (i.e. carbon monoxide) has been reported to cause symptoms such as headache, nausea and vomiting.[22] Other non-respiratory symptoms such as waist pain, body pain and dizziness could be linked to physical work stress.

The reduced lung function of *suya* meat sellers, marked by decreased FVC, FEV_1, FEV_1/FVC ratio and PEFR among the test subjects relative to the control subjects, is indicative of obstructive changes in the airways due to continuous inhalation of WSCOFumes. This observation is consistent with a previous study that reported decreased lung function indices in children exposed to wood smoke in a fishing port in South-South Nigeria.[23] In the present study, the lung function indices of the *suya* meat sellers decreased as their duration of work increased, indicating that the more the *suya* meat sellers were exposed to WSCOFumes, the more severe the impairment in their lung function was. This reflects in the negative correlation between FVC, FEV_1, FEV_1/FVC and PEFR and the duration of work. The impaired lung function indices of the *suya* meat sellers observed in this study can only be attributed to the WSCOFumes they were exposed to because both control and test subjects were non-smokers who lived in similar environments and had identical anthropometric parameters. [24,25] Despite the reduction in lung function indices of the test subjects, their oxygen saturation level was not significantly impaired.

The ambient air quality assessment showed that SO_2, NO_2 and Particulate matter ($PM_{2.5}$ and PM_{10}) were significantly higher in the environments where the test subjects worked compared to the environments of the control subjects. This observation can be attributed to wood smoke. Although particulates can be detected in many organs, such as the lungs, kidneys, brain, heart and liver, their deposition patterns show that the lungs are the primary sites. [26] According to Fann *et al.*,[27] there is no standard toxic dose for particulate matter, because of their numerous chemical and physical properties.[27] Therefore, even exposure to particulate matter at a concentration below the US national standards poses a significant health risk. Particulate matter has been known to penetrate the gas-exchange region of the lung and infiltrate the circulatory system through the layers of alveolar obstruction, [28] thereby, inducing various symptoms of pulmonary inflammation.[29] The resultant effect of this inflammation explains the reduction in the lung function indices of the *suya* meat sellers observed in our study.

Furthermore, previous studies have found that several carcinogens such as polycyclic aromatic hydrocarbons, aromatic amines and nitro-polycyclic aromatic hydrocarbons in cooking oil fumes [30] are associated with the risk for several cancers, including lung cancer.[31] In addition to having carcinogenic effects, exposure to chemicals from oil fumes condensates may cause airway injuries and inflammatory responses through their effect on oxidant and antioxidant imbalances and innate immunity impairment.[32] Cooking oil fumes-induced inflammatory response in the airways may lead to respiratory symptoms or lung function impairment. The reduction in the lung function parameters observed in the present study is probably because of inflammatory response and airway fibrosis evoked by the particulate matter in wood smoke and oil fumes.[33] The inflammation, in turn, led to the constriction of the bronchioles in the conducting pathways, thereby increasing mucus secretion and mucosal oedema and consequently reducing PEFR and FEV_1[34] when it involved large and medium-sized airways. When the whole part of the lungs is exposed to WSCOFumes over a long period, it may have resulted in reduced lung size with a subsequent decrease in FVC.[35]

Conclusion

Grilled meat (*Suya*) sellers in Calabar, Nigeria, have decreased lung function indices and a high prevalence of respiratory and non-respiratory symptoms, notably chest pain, sneezing, catarrh, headache, and waist pain. These symptoms could possibly have resulted from their exposure to wood smoke and cooking oil fumes during *suya* meat preparation. The impairment in their lung function is worse with increasing duration of exposure. There is a need for frequent/routine environmental and health check-ups or the provision of alternative methods for *suya* meat preparation for those engaged in the *suya* meat business.

Authors' Contribution: NJN and AAB designed the study. JAA, APU, and AEA analysed the data. UAL interpreted the data and wrote the first draft of the manuscript. All authors revised the draft manuscript for sound intellectual content and approved the final draft.
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