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Effects of Firewood, Kerosene and Gas Use on Some Cardiopulmonary and Anthropometric Parameters among Females in Samaru, Sabon Gari, Zaria

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ABSTRACT

This study evaluated the effects of exposure to constituents of firewood, kerosene, and liquefied petroleum gas on cardiopulmonary and some anthropometry parameters among women in Samaru area of Sabon Gari Local Government, Kaduna state. 300 female subjects of the age between 18-50 years participated in the research: 100 of which use firewood (group 1); 100 use kerosene stove (group 2); and 100 use liquefied gas stove (group 3/control). Simple random sampling technique was used to select the subjects. Auscultatory method was used for blood pressure measurement, peak flow meter was used for measurement of forced expiratory flow rate, while full body sensor machine was used to record body mass index, resting metabolism, visceral fat, body fat percentage and skeletal muscle percentage of the subjects. The result of this study showed the firewood users had significantly higher blood pressure than the rest of the groups, based on ANOVA. The peak expiratory flow rate of the groups that use firewood and kerosene were significantly lower ($p < 0.05$) compared to the group that use gas. The result of visceral fat was also significantly higher in the firewood group users, compared to kerosene and gas users. However, there was no significant difference ($p < 0.05$) in body mass index, resting metabolism, body fat percentage and skeletal muscle percentage between the three groups. In conclusion, the present study indicated that the use of firewood and kerosene for cooking purposes significantly affected cardiopulmonary parameters, which emphasizes the need for alternative, cleaner sources of energy in households that currently rely on firewood and kerosene.

Keywords: Kerosene stove, firewood, liquefied petroleum gas, cardiopulmonary, anthropometry.

INTRODUCTION

Indoor air pollution from the combustion of solid fuels, such as kerosene and firewood, is a major public health concern, particularly in low- and middle-income countries like Nigeria. Exposure to the combustion products of firewood, kerosene, and liquefied petroleum gas (LPG) can have significant effects on cardiopulmonary health. Indoor air pollution from these fuel sources contains a variety of pollutants such as particulate matter ($PM_{2.5}$), carbon monoxide, nitrogen oxides, and volatile organic compounds, which may accumulate overtime in body systems and cause adverse health outcomes (1).

Firewood is a common cooking fuel in many low- and middle-income countries including Nigeria. The incomplete combustion of firewood produces a range of indoor air pollutants, including fine particulate matter ($PM_{2.5}$), carbon monoxide, and volatile organic compounds, which have been linked to adverse health effects that can cause respiratory and cardiovascular diseases, as well as eye and skin irritation (1). Worldwide, at least 4.3 million people die per annum, from exposure to pollutants resulting from the burning of solid fuels (2). About 25% of global emissions of black carbon is generated from residential biomass combustion, the dark component of particulate matter and a short-lived pollutant that has strong visible light absorption properties (3, 4).

Kerosene, also known as paraffin is a fractional distillate of petroleum oil with a mixture of short-chain hydrocarbons. It is a type of liquid fuel commonly used for lighting, heating, and cooking in many parts of the world, particularly in developing countries where access to electricity and cleaner fuels is limited (5, 6). Kerosene fumes contain a range of toxic chemicals, including benzene, toluene, and xylene, which can damage the lungs and cause respiratory problems. Studies have linked kerosene exposure to lung cancer, chronic obstructive pulmonary disease (COPD), and asthma (7). A study conducted in Nigeria found that kerosene exposure was associated with increased oxidative stress and inflammation, which are key drivers of cardiovascular disease (8).

Liquefied petroleum gas (LPG) is a cleaner fossil fuel that emits lower levels of carbon and minimal fine particulate matter ($PM_{2.5}$) concentrations compared to firewood and kerosene, typically meeting WHO Indoor Air Quality Guideline levels for health (2). Studies have found that switching from traditional biomass fuels to LPG for cooking can lead to improved respiratory health outcomes. A systematic review and meta-analysis of some studies found that use of LPG for cooking was associated with reduced risk of cardiovascular disease compared to traditional solid fuels (9). However, the use of LPG for cooking and heating is still low in Nigeria due to its high cost (10).

Nigeria is one of the countries in sub-Saharan Africa where the use of solid fuels such as firewood and charcoal for cooking and heating is still prevalent, especially in rural areas. Kerosene and liquefied petroleum gas (LPG) are also commonly used for cooking and heating in both rural and urban areas (10). Constant exposure to the constituents of these fuels has been associated with adverse cardiopulmonary health outcomes. Little health related research has been conducted on the use of these cooking fuels in this part of Nigeria. Thus, this study aimed at determining changes that may occur in some cardiopulmonary parameters (blood pressure and expiratory flow rate) and anthropometry parameters (body mass index, visceral fat, body fat percentage and skeletal muscle percentage), which serves as markers to show the body's response to the effect associated with the use of firewood, kerosene and liquefied gas.

MATERIALS AND METHODS

Study Area: All subjects used in this research reside in Samaru area of Sabon Gari Local Government, Kaduna State, Nigeria. It is located on latitude 11˚ 15'N to 11˚ 3'N of the equator and longitude 7˚ 30'E to 7˚ 45'E of Greenwich Meridian. Subjects that use firewood were selected from Dogon iche area of Samaru. Subjects that use kerosene were selected from Ribadu and Amina hostels of Ahmadu Bello University Samaru Campus, while subjects that use gas were found in the off-campus area in Samaru.

Study Design and Study Population: This research was performed in line with the ethical committee guidelines of Ahmadu Bello University, Zaria, Nigeria and in accordance with the ethical standards of the University. The primary data were obtained by the use of questionnaires and other experimental techniques. A well-structured questionnaire of several variables was designed and administered to the target population. The variables contained in the questionnaire include: Subject consent form, sex and age of respondents and health status on cardiopulmonary diseases.

A total of 300 female subjects within the age of 18-50 years participated in the research which include: 100 firewood users (group 1); 100 kerosene stove users (group 2); and 100 liquefied gas stove users (group 3/control). All participants signed a written consent form and no complications were encountered during the study.

Sampling Technique: Simple random sampling technique was used in selecting the subjects and questionnaires were distributed to the participants where their personal information were entered.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria: All subjects were apparently healthy female individuals, willing to participate in the study.

Exclusion criteria: Subjects with any of the following health conditions were excluded: History of hypertension; restrictive or obstructive respiratory disease; chronic diseases; smokers and any mental illness.

Research instruments/materials: The following materials were used for this research: Mercury sphygmomanometer (product code: SMRI.1002LF), stethoscope, peak flow meter (S48917 vitalograph Ltd Buckingham, England), full body composition monitor and scale (Omron HBF-514C), measuring tape, cotton wool, disinfectant (methylated spirit).

Determination of Blood Pressure: Blood pressure was measured by auscultatory method, using a properly calibrated and validated sphygmomanometer and stethoscope following the principle described by (11). This method records both systolic and diastolic blood pressures based on the detection of Korotkoff sounds, named after Dr. Nikolai Korotkoff, a physician who described them in 1905. The subject was asked to sit and allowed to rest for 5 minutes for mental and physical relaxation. The cuff of the sphygmomanometer was placed around the subject's upper arm, with the centre of the bag lying over the brachial artery. The chest-piece (bell) of the stethoscope was placed on the bifurcation of brachial artery in the cubital space and the cuff was inflated rapidly, by compressing and releasing the air pump of the sphygmomanometer to raise the pressure to about 40 to 50 mmHg above the systolic level. The pressure was then gradually lowered until a clear, sharp, tapping sound is heard, known as the Korotkoff sounds. The level at which the first sound is heard, was taken as the systolic pressure, while the diastolic pressure was taken at the level of the disappearance of the sounds. The blood pressure is recorded as systolic/diastolic in mmHg, with normal blood pressure in healthy adult males being 120/80 mmHg.

Determination of Peak Expiratory Flow Rate: The peak expiratory flow rate was measured using a peak flow meter, based on the principle described by American Lung Association (12). The peak flow meter is a small handheld plastic device, with a pointer that moves in a slot alongside a scale with numbers in liters/min.

The subjects were asked to hold the peak flow meter by its handle, take a deep breath and place the mouthpiece firmly between the teeth and lips. The subject then blows out with a short sharp blast into the mouthpiece. The reading on the scale was recorded. The procedure was repeated twice at intervals of 1 minute and the average value recorded as the subject's peak expiratory flow rate. The mouthpiece of the peak flow meter was disinfected after each use before the next subject takes her turn. Normal range of expiratory flow rate is 400 liters/minute, with a range of 320–600 liters per minute.

Determination of Body Mass Index (BMI), Body Fat Percentage, Skeletal Muscle Percentage, Resting Metabolism and Visceral Fat: Body mass index (BMI) is defined as body weight measured in kilograms divided by the square meter of height. The height of the subject was measured using a measuring tape and the values of the height and age of the subject was recorded into a machine called FULL BODY SENSOR (body composition monitor and scale). The subject was then requested to stand bare foot on the full body censor composition and scale machine, with her heels positioned on the heel electrodes, her knees and back standing upright and looking straight ahead. The arms were raised horizontally and her elbows extended straight to form a 90° angle with her body. The machine was then switched on and within a minute, the machine automatically gives the results of BMI [weight (kg)/height (m^2)], (13); body fat percentage (fat mass / body weight) (14); skeletal muscle percentage; and the visceral fat. The values of the above parameters are displayed on the display unit of the full body sensor device.

Statistical Analysis: Data collected was expressed as Mean ± Standard Error of Mean (SEM). It was analysed using one way analysis of variance (ANOVA) and Tukey's post hoc test was used to compare the level of significance between the groups, using statistical package for social sciences

(SPSS) version 23. Values were considered statistically significant at $p \leq 0.05$.

RESULTS

Blood Pressure and Peak Expiratory Flow rate: The results of systolic blood pressure, diastolic blood pressure and peak expiratory flow rate of females that use firewood, kerosene, and gas in Samaru, Zaria is presented in table 1 below. The result of this study showed significantly higher values in blood pressure ($p < 0.05$) of the women that use firewood (systolic blood pressure of 129.32 mmHg ± 1.78 and diastolic blood pressure of 84.34 mmHg ± 12.29), when compared to the groups that use kerosene (systolic value of 118.69 mmHg ± 0.10 and diastolic value of 75.86 mmHg ± 8.69) and the group that use gas (systolic value of 115.49 mmHg ± 0.81 and diastolic blood pressure of 77.65 mmHg ± 8.59). As regard to peak expiratory flow rate, it was significantly lower *($p < 0.05$)* in the group that use firewood (323.75 L/min ± 5.96) and kerosene (338.40 L/min ± 7.05), compared to the group that use gas (359.15 L/min ± 6.81).

Table 1: Effects of firewood, kerosene and gas use on systolic blood pressure, diastolic blood pressure and peak expiratory flow rate among females in Samaru, Zaria

Group	SBP (mmHg)	DBP (mmHg)	PEFR (L/min)
Fire Wood	129.32 ± 1.78^{a}	84.34 ± 12.29^{a}	323.75 ± 7.05^{a}
Kerosene	118.69 ± 0.10^{b}	77.65 ± 8.59^{b}	338.40 ± 5.96^{a}
Gas (control)	115.49 ± 0.81^{b}	75.86 ± 8.69^{b}	359.15 ± 6.81^{b}

Different superscript letters "$^{a,\ b}$" indicate statistically significant difference ($p \leq 0.05$) between the groups, while the same superscript letters "$^{a,\ a}$" or "$^{b,\ b}$" indicate no statistically significant difference ($p > 0.05$) between the groups.

SBP = Systolic Blood Pressure

DBP = Diastolic Blood Pressure

PEFR = Peak Expiratory Flow Rate

Body Mass Index (BMI) and Resting Metabolism: Table 2 shows the result of body mass index and resting metabolism of females that use firewood, kerosene, and gas in Samaru, Zaria. The results of this study shows there was no significant difference *($p < 0.05$)* in these parameters between the three different groups.

Table 2: Effects of firewood, kerosene and gas on resting metabolism and body mass index (BMI) among females in Samaru, Zaria

Group	RM (kcal)	BMI (kg/m^2)
Fire Wood	1276.81 ± 15.84	26.96 ± 0.60
Kerosene	1261.03 ± 11.85	24.84 ± 1.88
Gas (control)	1283.55 ± 16.65	25.82 ± 2.40

BMI= Body Mass Index

RM= Resting Metabolism

Body Fat Percentage, Skeletal Muscle Percentage and Visceral Fat: The results of body fat percentage and skeletal muscle percentage presented in table 3 below shows no statistically significant difference between the three groups. However the visceral fat of the group that use firewood (7.24 ± 0.32) was significantly higher *($p < 0.05$)*, compared to the other two groups that use kerosene (3.95 ± 0.14) and gas (4.26 ± 0.16).

Table 3: Effects of firewood, kerosene and gas on body fat percentage, skeletal muscle percentage and visceral fat among females in Samaru, Zaria

Group	BFP (%)	SMP (%)	VF
Fire Wood	39.49 ± 0.91	26.08 ± 1.79	7.24 ± 0.32^a
Kerosene	37.09 ± 3.39	26.42 ± 0.28	3.95 ± 0.14^b
Gas (control)	37.94 ± 2.86	25.36 ± 0.39	4.26 ± 0.16^b

Different superscript letters "$^{a,\ b}$" indicate statistically significant difference ($p \leq 0.05$) between the groups. While the same superscript letters "$^{b,\ b}$" indicate no statistically significant difference ($p > 0.05$) between the groups.

BFP= Body Fat Percentage

SMP= Skeletal Muscle Percentage

VF= Visceral Fat

DISCUSSION

Effects of Fire Wood, Kerosene and Gas Use on Blood Pressure: This research studied the changes that may occur in some cardiopulmonary parameters (blood pressure and expiratory flow rate) and anthropometry parameters (body mass index, visceral fat and skeletal muscle mass) in women that use either firewood, kerosene or liquefied petroleum gas as cooking fuel. All the women in this research reside in Samaru area of Sabon Gari Local Government, Kaduna.

This study showed that the group that use firewood as a cooking fuel had a significantly higher ($p \leq 0.05$) systolic blood pressure (129.32mmHg ± 1.78) and diastolic blood pressure (84.34mmHg ± 12.29), when compared to the second group that use kerosene (having systolic blood pressure of 118.69mmHg ± 0.10 and diastolic blood pressure of 75.86mmHg ± 8.69) and the third group that use gas (systolic blood pressure of 115.49 mmHg ± 0.81 and diastolic blood pressure of 77.65mmHg ± 8.59). Though there was a slight increase in the group that use kerosene compared to the group that use gas, the increase was not statistically significant. The increase in blood pressure of firewood users may be as a result of exposure to pollutants produced from the incomplete combustion of firewood, which is known to emit a range of indoor air pollutants, including particulate matter, carbon monoxide, and volatile organic compounds (1). These pollutants are known to cause respiratory and cardiovascular diseases. This result is in consistence with the study by (15), which found that women in Guatemala who used firewood for cooking had higher levels of blood pressure, carotid intima-media thickness, and C-reactive protein (a marker of inflammation), compared to those who used liquefied petroleum gas. This is also supported by (16), who showed that particulate matter from firewood increases blood pressure and a toxicological study that showed wood smoke exposure has a potential of blood pressure elevation (17). From the result, it can be inferred that using gas is safer than using kerosene or firewood. Liquefied petroleum gas (LPG), mostly referred simply as gas is a cleaner-burning fuel that produces fewer pollutants than firewood. A systematic review and meta-analysis of 16 studies found that use of LPG for cooking was associated with reduced risk of cardiovascular disease compared to traditional solid fuels (9). Another study conducted in India found that switching from firewood to LPG reduced indoor air pollution levels by 90% and improved respiratory health outcomes in women and children (18). According to the international energy agency for energy balance, in 2015, about 80-90% of house hold cooking sector in rural areas in Nigeria use biomass fuel particularly fire wood as a source for energy. Strategies to promote the use of cleaner-burning fuels, such as LPG, and reduce exposure to solid fuels, such as firewood, are needed to improve cardiopulmonary health in Nigeria.

Effects of Fire Wood, Kerosene and Gas Use on Peak Flow Rate: The result of this study showed a significantly lower value *($p < 0.05$)* of peak expiratory flow rate (PEFR) in the group that use firewood (323.75 L/min ± 5.96) and kerosene (338.40 L/min ± 7.05) when compared to the group that use gas (359.15 L/min ± 6.81). The lowest values of PEFR were associated with the use of firewood, followed by kerosene use. PEFR is the measure of the functioning of the larger airways and any obstruction caused by stress, inflammation or infection in these airways can cause adverse reactions in the respiratory system (19). Firewood and kerosene fumes contains toxic chemicals, such as particulate matter, carbon monoxide, volatile organic compounds, benzene and toluene that can result in high levels of indoor air pollution. This can cause damage to the lungs and respiratory tract, which can exacerbate respiratory problems (1, 20). The result of this study showed that using gas as a cooking fuel did not significantly affect the PEFR of the subjects, which implies that LPG is a cleaner cooking fuel compared to kerosene and firewood. A study by (9) stated that, compared to kerosene and firewood, LPG is a cleaner-burning fuel that produces lower levels of pollutants and also found that switching from traditional biomass fuels to LPG for cooking can lead to improved respiratory health outcomes. This result is in consistence with the work of (6), that showed that exposure to kerosene fumes was associated with increased risk of respiratory symptoms, including cough and shortness of breath, associated with reduced lung function. This is also in agreement with a study by (21), which demonstrated that exposure to biomass fuel among rural women in southern Nigeria was associated with lower PEFR.

Effects of Firewood, Kerosene and Gas Use on Body Mass Index (BMI) and Resting Metabolism: The results of this study showed no significant difference in basal metabolic rate (BMI) between the group that use firewood (25.82 kg/m^2 ± 2.40), kerosene (24.84 kg/m^2 ± 1.88) and gas (25.82 kg/m^2 ± 2.40). Basal metabolic rate is the minimum level of energy expended to sustain life and is typically measured shortly after sleep but before arousal (22). According to (23), BMI is associated with body fat percentage. The results of this study also showed no significant change in body fat percentage, which may account for the reason why no changes were observed in the BMI.

The results also showed no significant difference in resting metabolism of the group that use firewood (1276.81 kcal ± 15.81), kerosene (1261 kcal ± 11.85) and gas (1283.55 kcal ± 16.65). Resting metabolism, also known as resting metabolism rate refers to the amount of calories burned from normal physiological functions, representing the largest component (60-80%) of total daily expenditure in humans, with sedentary individuals displaying a higher relative contribution due to lower levels of physical activity, hence lower energy expenditure (24). This result corresponds with the study carried out by (25), which indicated that exposure to volatile organic compounds did not significantly affect resting metabolism.

Effects of Firewood, Kerosene and Gas Use on Visceral Fat: The result showed the visceral fat was significantly higher in the group that use firewood (7.24 ± 0.32) when compared to the group that use kerosene (3.95 ± 0.14) and gas (4.26 ± 0.16). Visceral adipose tissue has been proposed to be the most important fat depot related to unfavorable lipid profile (26). It was reported that visceral fat accumulation closely correlates with systolic blood pressure and is an independent risk factor for future myocardial infarction in elderly women (27). In this present study, firewood users were seen to have higher blood pressure, which can be associated to the increased visceral fat depot.

Effects of Firewood, Kerosene and Gas Use on Body Fat Percentage and Skeletal Muscle Percentage: The body fat percentage of the group using firewood (39.49 ± 0.91), kerosene (37.09 ± 3.39) and gas (37.94 ± 3.390) showed no significant difference between the groups. Body fat percentage is the proportion of individual fat mass over body weight. It reflects more accurate body composition than body mass index (BMI) and both parameters have been used for the evaluation of human health risks such as cardiovascular risk in clinical practice (14).

The value of the skeletal muscle percentage of firewood users (26.08 ± 1.79), kerosene users (26.42 ± 1.79) and gas users **(**25.36 ±

0.39) also showed no significant difference among the groups.

More high-quality studies are needed to better understand the relationship between firewood smoke and kerosene fume exposure on these parameters, using standardized methods to measure the level of exposure to pollutants. Other confounding factors, such as diet and physical activities of the subjects should also be considered.

CONCLUSION

In conclusion, the findings of this study demonstrate that using firewood and kerosene for cooking is associated with substantial negative impacts on cardiopulmonary health, while liquefied petroleum gas poses no adverse health effects. This highlights the necessity of introducing alternative, cleaner energy sources in households currently reliant on kerosene and firewood, aiming to mitigate health hazards associated with indoor air pollution.

RECOMMENDATIONS

1. Reducing exposure to indoor air pollution can improve cardiovascular and respiratory health, and reduce the risk of cardiopulmonary problems, particularly for women who spend significant time cooking indoors.
2. Further research encompassing longitudinal studies and intervention trials would be beneficial to establish causality and provide evidence-based information, with the objective of improving indoor air quality, cardiovascular and respiratory health for women in different cooking settings.
3. To mitigate the adverse effects of traditional cooking fuels, there is need to emphasize awareness and education about the harmful effects of kerosene and firewood on respiratory and cardiovascular health, particularly among vulnerable populations.

CONFLICT OF INTEREST

The authors declare that no conflict of interest is associated with the information presented in this paper.

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