Comparative Study of Haematological and Cardiorespiratory Parameters in Women Exposed to Biomass or Mixed Fuels

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Abstract

Wood-burning stoves have been a popular cooking and heating source for decades, but unfortunately they can emit substantial quantities of pollutants to outdoor and indoor air. The aim of this study was to compare the effect of biomass fuel and mixed fuels on cardiovascular and haematological indices of women exposed to the combustion products of these fuels. Blood samples were collected from 52 women who used biomass fuel and from 77 women who used mixed fuels. There was no significant difference between the groups for most parameters except for cardiovascular, peak expiratory flow rate and mean corpuscular volume, which were significantly higher in women that use mixed fuels. It has been reported that the effect of wood smoke increases with years of exposure and level of exposure, as well as with the type of biomass fuel used.

Keywords: Haematology; Biomass fuel; Blood pressure; Heart rate; Mean arterial blood pressure

Introduction

Biomass fuel is used by half of the world's population as a source of fuel, especially in the developing world.

Biomass exposure is the inhalation of any gaseous or particulate emission from biomass burning involving multiple types of fuels from different woods, grasses, crop residues and animal dung. A survey conducted by the National Bureau of Statistics showed that in 2008 74.1% of households in Nigeria used wood as a source of cooking fuel, 0.7% electricity, 0.7% gas, 22.9% kerosene and 1.6% coal. In 2009, there was an increase in the use of wood to 79.6% representing a significant shift from other sources of cooking fuels (Perez-Padilla, *et al* 1996;Ramlogan 1997; Ramirez-Venegas, *et al* 2006; Montano, *et al* 2010, Morandi and Ward 2010).

Biomass fuels have been used in Africa for as long as can be remembered. These fuels have been associated with indoor and outdoor pollution, releasing substances including particulate matter, inorganic gases such as carbon monoxide, nitrogen oxides, sulphur dioxide, volatile organic hydrocarbons and polycyclic aromatic compounds. Wood smoke and diesel particles have very comparable total carbon content but the organic content is higher in wood smoke than in diesel particles. There is considerable epidemiological evidence linking biomass pollution with several indices of health outcomes, including chronic obstructive pulmonary disease (COPD) and other respiratory diseases. Research shows that COPD developed from individuals exposed to biomass smoke continues many years after exposure(Bruce, *et al* 2000; Kocbach, *et al* 2006;Rinne, *et al* 2006; Montano, *et al* 2010; Nielsen, *et al* 2007).

There is paucity of information on the association between the use of biomass fuel, haematological and cardiovascular changes in domestic biomass users. De Paula Santos et al (2005) reported that most of the studies conducted were on well-known susceptible groups such as the elderly, people with COPD and/or cardiac diseases or unusual exposure levels. The primary aim of this study was to compare cardiovascular and haematological indices of biomass and mixed fuel users, and to obtain data in women in Nigeria. Such information is scanty or lacking completely in the available literature.

Materials and methods

The study was carried out in Ahmadu Bello University, Zaria, Nigeria. A total of 129 women, who volunteered to participate in the study served as subjects. The women were grouped according to the type of domestic fuel used: biomass (n=52) or mixed fuel (n=77) group. Mixed fuel comprises liquefied petroleum gas, electricity and kerosene. All the women who used mixed fuels had been exposed to biomass fuel at some time, but were currently using mixed sources of fuel. Exclusion criteria included all smokers, pregnant women and women with any respiratory disorder, pulmonary arterial hypertension or recent surgery. Ethical clearance was given by the Ethical Committee, Ahmadu Bello University Teaching Hospital, Zaria.

Anthropometry

The age of each subjectwas calculated from the last birthday.Weight in kilograms was determined using a floor scale for mobile use to weigh the women standing straight and wearing light clothes. Height in centimetres which was later converted to meters was measured using the measuring tape. Body mass index was calculated using the formula:**BMI** (kg/m^2) = Mass (kg) / (height (m)) ^{2}.

Blood collection

Two milliliters (2 ml) of venous blood was collected from theantecubital area into tubes containing 1.8mg of EDTA per 1ml of blood under normal standard conditions. The samples were analyzed in the Department of Haematology, Ahmadu Bello University Teaching Hospital, using an automated analyzer (Sysmex XT 2000*i*,Wakinohama, Japan).

Blood pressure

The women were seated, relaxed and with arms well supported, and resting blood pressure [systolic blood pressure (SBP) and diastolic blood pressure (DBP)] was measured by manual auscultation using a sphygmomanometer. Pulse rate was measured and mean arterial blood pressure were calculated according to NICE guidelines (Ritchie, *et al* 2011).

Lung function tests

Spirometry tests was carried out on the subjects using the Spirolab II in accordance with the American Thoracic Society's recommendation, this cycle was repeated 3 more times and the best test result was selected by the Spirolab.

Respiratory parameters, forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced expiratory volume in 1 second percentage ($FEV_{1\%}$), $FEF_{25-75\%}$ and peak expiratory flow rate (PEFR) where obtained from the two groups.

Statistical analysis

Data are presented as mean ± SEM (standard error of mean). Values were compared using Student's t test and considered significant if P was less than 0.05. Pearson's correlation was used to determine the association between the groups. SPSS software version 17 for Windows computing programme was used for statistical analysis.

Results

Anthropometric data of the women are presented in Table 1 Biomass and mixed fuel users were matched for age and height ($p > 0.05$). Weight and BMI were significantly higher in the mixed fuel users compared to biomass users (Table I). Age was found to be positively correlated with systole (r=0.659), MABP (r=0.622) and BMI (r=0.899), but negatively correlated to FEV_1 (r=-0.549). Biomass as a source of fuel is being used by biomass users for an average of 4hours/ day.

Table1. Anthropometric indices of women who use mixed fuels or biomass to cook

	Mixed (n=77)	**Biomass (n=52)**	**P value**
AGE (yrs)	43.68± 1.093	42.08± 1.560	>0.05
WEIGHT (kg)	79.97± 2.110	66.96± 1.800	<0.001**
Height (m)	1.81± 0.195	1.58± 0.009	>0.05
BMI (kg/m^2)	30.23± 0.865	26.81±0.664	<0.01*

Mean ± SEM, BMI= body mass index, * *p<0.05, **p<0.001*

As shown in Table 2 blood pressure parameters, (systole, diastole, pulse rate and MABP) were all significantly higher in biomass fuel users, when compared between the two groups (P>0.001). BMF users were found to be systolic prehypertensives, while diastole, pulse rate and MABP remained within normal physiological range.

Table2. Blood pressure parameters of women who used mixed fuels or biomass to cook

	Mixed n=77	**Biomass n=52**	**P value**
SBP (mmhg)	130.03± 1.583	139.42± 1.881	<0.001**
DBP (mmhg)	79.31± 0.669	82.60± 0.746	<0.01*
PULSE (beats/min)	76.65± 0.221	78.039± 0.241	<0.001**
MABP (mmhg)	96.22± 0.858	101.54±1.011	<0.001**

Mean±SEM. SBP: systolic blood pressure, DBP: diastolic blood pressure, MABP: mean arterial blood pressure.**p>0.05, **p>0.001*

Table 3 showing the lung function parameters of FVC, FEV_1 and FEF showed no significant difference between the groups but PEFR and $FEV_{1\%}$, (3.948± 0.191 and 95.03± 0.905 respectively) was significantly higher in biomass users when compared between the groups.

Table 3 Lung function parameters of women who use mixed fuels or biomass to cook

	Mixed (n=77)	**Biomass (n=52)**	**P value**
FVC(L)	2.117± 0.837	1.903± 0.072	>0.05
FEV_1(L)	1.946± 0.085	1.805± 0.068	>0.05
PEFR(L/s)	3.475± 0.153	3.948± 0.191	<0.05*
$FEV_{1\%}$	91.53± 1.144	95.03± 0.905	<0.05
$FEF_{25-75\%}$(L/s)	2.523± 0.111	2.522± 0.123	>0.05

FVC: forced vital capacity, FEV_1: forced expiratory volume in 1 second, PEFR: peak expiratory flow rate, $FEV_{1\%}$: forced expiratory volume in 1 second percentage, $FEF_{25-75\%}$: forced expiratory $flow_{25-75\%}$.Mean±SEM. **p>0.053.475± 0.1533.948± 0.191*

There were no significant differences in the values of haematological indices that were investigated, namely PCV, MCHC,Hb, RBC, MCV, WBC. The counts of lymphocytes, monocytes, neutrophils and eosinophils showed no statistically difference, except for MCH which was significantly higher ($p< 0.05$) than that of mixed fuels users (Tables' III and IV).

Table4 Red blood cell parameters of women who use biomass or mixed fuels to cook.

	Mixed (n=77)	Biomass (n=52)	P value
RBC(10^{12}/L)	4.33± 0.061	4.23± 0.929	>0.05
PCV (%)	37.13± 0.004	36.25± 0.007	> 0.05
MCHC(g/dL)	33.86± 0.663	33.12± 0.112	> 0.05
HB(g/dL)	12.30± 0.163	12.00±0.255	> 0.05
MCH (*pg*/cell)	28.67± 0.162	28.12± 1.147	< 0.05*
MVC(fL)	85.61± 0.349	85.14± 0.416	> 0.05

RBC (red blood cell count), PCV (packed cell volume), MCHC (mean corpuscular haemoglobin concentration), Hb(haemoglobin concentration), MCH (mean corpuscular haemoglobin), MCV (mean corpuscular volume). Mean±SEM. *$*p<0.05$*

Table5: Total and differential white blood cell counts of women who used biomass or mixed fuels to cook. No difference was found between the two groups for all the parameters.

	Mixed n=77	Biomass n=52	P value
WBC (10^9/L)	4.95± 0.161	5.22± 0.231	> 0.05
NEUTROPHILS (%)	49.78± 0.837	50.92± 0.844	> 0.05
MONOCYTES (%)	3.00± 0.294	2.71± 0.322	> 0.05
LYMPHOCYTES(%)	48.57± 0.852	47.5± 0.873	> 0.05
EOSINOPHILS (%)	2.22± 0.208	3.13± 0.506	> 0.05

Discussion

Anthropometric indices of mixed fuel users and BMF users are shown in Table 1. Both groups were the same in respect to age and height, but they differed significantly in weight and BMI. Mixed fuel users were found to be heavier and had a higher BMI of 30.23± 0.865 (class- over weight). BMI has been associated with socio-economic status based on the finding that women who use BMF fuels are of lower class, with less income and lower educational achievements(Regalado, *et al* 2006). Women in this study were mainly cooks, causal workers with low income, when compared with women that used mixed fuels, who are in a higher socio-economic status and have better pay, and therefore can afford more refined fuels than biomass.

BMF users had significantly higher values of cardiovascular parameters (SBP, DBP, pulse rate and MABP) whichfell within the normal physiological range, except for SBP value which showed that they were presystolic hypertensives (139.42± 1.881). The findings of the present study agrees with the result of study conducted on women in Guatemala that were randomly assigned to cook with the *plancha*-improved stove, instead of the traditional open fire, who had lower SBP and DBP values(McCracken, *et al* 2007). Oxidative stress and systemic inflammation are central to leading mechanistic hypothesis for effects of fine particles on cardiovascular health (Brook, *et al* 2004). Evidence of increased reactive oxygen species concentration in the heart and lungs of rats exposed to concentrated ambient particles supports this hypothesis (Gurgueira et al., 2002). Providing a mechanistic link to blood pressure, endothelin-1, which modulates systemic vascular tone, is known to increase in response to reactive oxygen species. Further studies also show that heart rate can be susceptible to effects of air pollution, but most of the works have been done on groups such as the elderly, people with COPD and / or cardiac diseases or even unusual exposure levels (Pollitt, *et al* 2007).

Another hypothesis explain the effects of air pollutants on cardiovascular disease by relating changes in blood makers associated with increased cardiovascular risks, ischaemic response in the myocardium and effects on autonomic nervous system, which are themselves related to blood pressure and heart rate variability changes (de Paula Santos, *et al* 2005).

Two different pathways have been related to vascular constriction, one of them is based on the induction of reflex increase in the activity of the sympathetic nervous system and the other is the acute increase in the release of vascular endothelin. It is possible that air pollution promote vascular constriction through both mechanisms (Ibald-Mulli et al 2001; Brook et al 2002; Pekkennenet al 2002). There is a paucity of data on the association between cardiovascular disease and biomass fuel. McCracken et al.2007 reported that there was an increase in diastolic blood pressure in Guatemalan women, exposed to biomass smoke. It is known that particulate air pollution leads to rapid and significant increases in fibrinogen, plasma viscosity, platelet activation and release of endothelins. Also Pope et al. 2004 showed that PM exposures were most strongly associated with mortality due to ischaemic heart disease, dysrhythmias, heart failure and cardiac arrest.

Neutrophils are the most abundant leucocytes and one of the functions of eosinophils is in allergic reactions, which are important for phagocytosis and destruction of invading pathogens.Most evidence on effects of air pollution comes from studies of diesel exhaust (DE). Thus, the result of the present study agrees with the previous findings that short-term exposure to DE for 1 h induced an acute inflammatory response in the airways of healthy human volunteers. The present study also supports the finding that an increase in the concentrations of histamine and fibronectin in the bronchoalveolar lavage fluid (BALF), was elevated by DE which inducedleukocytic infiltration in the airways, involving neutrophils, lymphocytes, and mast cells (Salvi, *et al* 1999, Salvi, *et al* 2000). The findings of the present study also supports some studies carried out on laboratory animals and in human volunteers, which documented abnormal red cell, neutrophil and platelet levels, increased blood viscosity, changes in the number of T-lymphocytes, B-lymphocytes, and NK cells, increased pulse rate and lower heart rate variability in response to air pollution exposure (Pope III, *et al* 1999; Salvi, *et al* 1999;Gold, *et al* 2000;Schwartz, *et al* 2001; Banerjee, *et al* 2011).

Most physiological parameters are affected by anthropometric indices including age, weight, height, race, sex. In this study, although subjects were within the same age and height group, weight and BMI were significantly higher in mixed fuel users. BMI has been associated with socio-economic status, women using biomass fuels being of lower class, with less income and lower educational achievement. Socio-economic status has also been repeatedly associated with worse cardiovascular disease risk factor profiles and health behaviors, as well as with mortality from other diseases, including respiratory diseases (Prescott and Vestbo 1999; Regalado, *et al* 2006; McCracken, *et al* 2007; Pollitt, *et al* 2007).

Haematological parameters showed no significant differences between the two groups, except for MCH which was higher in women who use mixed fuels but were still within normal physiological range.

Overall the greatest limitation of this study is the lack of a control group; that is, women who have never had any contact with or used biomass fuels at one time or other in their life. In Africa and Nigeria in particular, 79.6% of households use biomass as their primary source of fuel therefore making it difficult to find an unexposed group. Also, the high incidence of various infections makes it difficult to distinguish the effect of biomass use and other factors that may increase or decrease the values of blood parameters. Further studies may be done, concentrating on women who have not had contact with biomass for an average of 10 years or more, who could be used as control without other exclusion criteria.

In conclusion, this study observed no relevant difference in haematological parameters, but a significant increase in cardiovascular parameters which were not physiologically increased above normal. Also no significant correlation was found between cardiovascular, respiratory and haematological parameters. Future studies could investigate oxidative effects such as Comet assay, Malondialdehyde concentration, Catalase just to mention a few tests, on haematological indices.

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Conflict of interest

No conflict of interest

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