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Hypertensive and toxicological health risk among women exposed to biomass smoke: A rural Indian scenario

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ABSTRACT

This study shows that exposure to air pollutants from indoor cooking fuel combustion may be associated with elevated Diastolic Blood Pressure (DBP), Systolic Blood Pressure (SBP), Heart rate and Body mass index (BMI) in rural women of India. 60 premenopausal women (using solely agriculture residues, wood, dung, straw, leaf) and 30 women (solely using clean fuel, LPG) were recruited for this study. An ethically approved questionnaire was used in the study and health parameters were measured by standard instruments. Eight pollutants were measured by calibrated instruments, applied both in the living room as well as kitchens of test-subjects. The Test-subjects were divided into two groups, LPG users, and biomass users, and the toxicological risk was assessed by measurement of $PM_{2.5}$ levels in the given indoor environments. The concentrations of all the pollutants were significantly ($p < 0.001$) higher in biomass users than in LPG using households, except in the case of O_3 ($p < 0.40_3$) at the time of cooking. Results highlighted that DBP ($p < 0.070$), SBP ($p < 0.143$), Heart rate ($p < 0.002$) and BMI ($p < 0.052$) were varied in the two fuel user groups. In the case of biomass fuel user toxicological risk was higher (5.21) than LPG users (0.69). Moreover, Symptoms like asthma (25%), cough (76.67%), dizziness (36.67%), eye irritation (88.33%), and shortness of breath (43.33%) were highly prevalent among biomass users than in LPG users. The study highlighted that Biomass using women are more prone to cardiovascular disease and policies should be formulated for their sustainable health.

1. Introduction

A major part of the world still relies on the combustion of biomass (crop residues, wood, and animal dung) (Ezzati, 2017). In India, more than 80% of the rural population use biomass-combusting ovens and stoves to prepare food and keep their house warm. Typical biomass materials used are wood, animal dung, and agricultural waste. In the developing world, the indoor combustion of biomass fuels may account for at least 2 million deaths per year (Chakraborty et al., 2014). According to the World Health Organization (2007), about 3.5% of the Indian national burden of disease and 0.4 million deaths result as consequence of indoor pollution by biomass combustion. Due to the economic crisis, people cannot afford cleaner fuel like electricity or liquefied petroleum gas (LPG). Moreover, inhabitants cannot afford cleaner energy sources, such as electricity of LNG, and use improperly ventilated indoor spaces with inefficient stoves (Du et al., 2017) which emit a mixture of particulate matter ($PM_{2.5}$ and PM_{10}) blended with toxic gases such as O_3, SO_2, and NO_2. A surplus of CO_2 and CO occurs also in the indoor environments, reducing air quality and particularly affecting the health of children and elders (Gautam et al., 2016). Research suggests that in a typical Indian household, the concentration of particulate pollutant while cooking with biomass in a traditional stove with the absence of ventilation can reach levels several times higher than the air quality standard recommended by the US Environmental Protection Agency (Balakrishnan et al., 2002; Chakraborty and Mondal, 2017). Another important point is that a large number of poor families in the villages do not possess a separate kitchen, however, they are habituated to do the cooking in a small space adjacent to their living room.

It was reported that rural people usually smoke in their bedroom. Research suggests that exposures to outdoor air pollution and smoke from tobacco have been associated with increased risk of myocardial infarction, stroke, and cardiovascular mortality (Barnoya and Glantz, 2005; Brook et al., 2010; U.S. Department of Health and Human Services, 2006). Pope et al. (2004) proposed many mechanisms for PM-induced increases in blood pressure (BP). Human experiments (Brook et al., 2009; Linn et al., 1999; Liu et al., 2009) suggest that interference with outdoor air pollution exposure could raise systolic BP (SBP) and diastolic BP (DBP), although subsequent studies failed to replicate these findings (Brauer et al., 2001; Ebelt et al., 2005; Harrabi et al., 2006). On

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the other hand, (Behera, 1997; Singh et al., 2017) reported that biomass smoke exposure can decrease lung function and increase interstitial lung disease. However, these phenomenon are predominant in western population but the cardiovascular physiology of the Indians and their socioeconomic status are different. Since these variables are known to influence lung activity (Harik-Khan et al., 2001; Dutta and Ray, 2014), results obtained from Western studies may not be relevant to the Indian situation. Hence, epidemiological studies are required among Indian population to examine the effect of air pollution on the pulmonary health status. Accordingly, this study was undertaken with four main aims: (1) to examine how the women exposed to IAP from biomass burning differed from the LPG users in the prevalence of different hypertensive condition, (2) to relate changes in cardiovascular health with different pollutant level inside the kitchen and living room, (3) assessment of toxicological risk from $PM_{2.5}$ and (4) to find out some strategic plan that how can the pollution be reduced and women get less exposure.

2. Materials and methods

2.1. Study area

This study was carried out in the Geriakula village of Bankura district, West Bengal, India (Fig. 1). LPG user was selected from Barrackpore from district North 24 Parganas, West Bengal, India (n = 30). For this study, the participating households were selected at random from among solid biofuel using villagers (n = 60). The rural households were chosen on the basis of the following criteria (i) That they were involved in cooking at least two years in the same kitchen, (ii) The location should be around 10 km away from the national highway to minimize the effect of vehicular pollution and (iii) No air-polluting industry like thermal power plant, cement factory, sponge iron factory, rice mill exists within a 10-km radius in order to exclude the impact of industrial pollution. All the households were almost similar in structure. They were more or less square in structure with walls and floors made of mud and, having a single door and window each. Stoves made up with mud were used by the villagers. All these stoves were fixed in a place (Fig. 2a). During the study, it was also observed that the villagers were collecting the fuel wood from the nearby forest areas (Fig. 2b).

2.2. Ethical approval

For this study ethical approval (IEC/BU (2016/1)) was granted by the Ethical Committee Board of the University of Burdwan.

2.3. Inclusion and exclusion criteria

The inclusion criteria were apparently healthy, married and unmarried, non-smoking, tobacco non-chewing women who engaged regularly in cooking purposes with either biomass or LPG for the past 5 years or more. Exclusion criteria were pregnant women or those currently under medication and women with family history of cardiovascular diseases.

2.4. Measurement of health parameters

Systolic, diastolic blood pressure and heart rate levels were measured while the participants were at rest in a sitting position by using an automated device (Accu Sure; brand Dr. Gene). Guideline of the British Hypertension society was followed for blood pressure measurement (O'Brien et al., 1997). The hypertension condition was judged by following the recommendation of WHO, (2003). The hypertensive condition was confirmed when SBP rose to 140 mmHg or more, or DBP elevated to 90 mmHg or more. For consistent measurement of each participant, we made three blood pressure measurements with an interval of 12 h (Fig. 2c). BMI was measured by weighing machine and height was measured by measuring tape. BMI was calculated by dividing body weight (kg) by height squared (m^2). BMI was categorized in four-level underweight (BMI $\leq$ 18 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI, 25–29.9 kg/m^2), and, obese (BMI $\geq$ 30 kg/m^2).

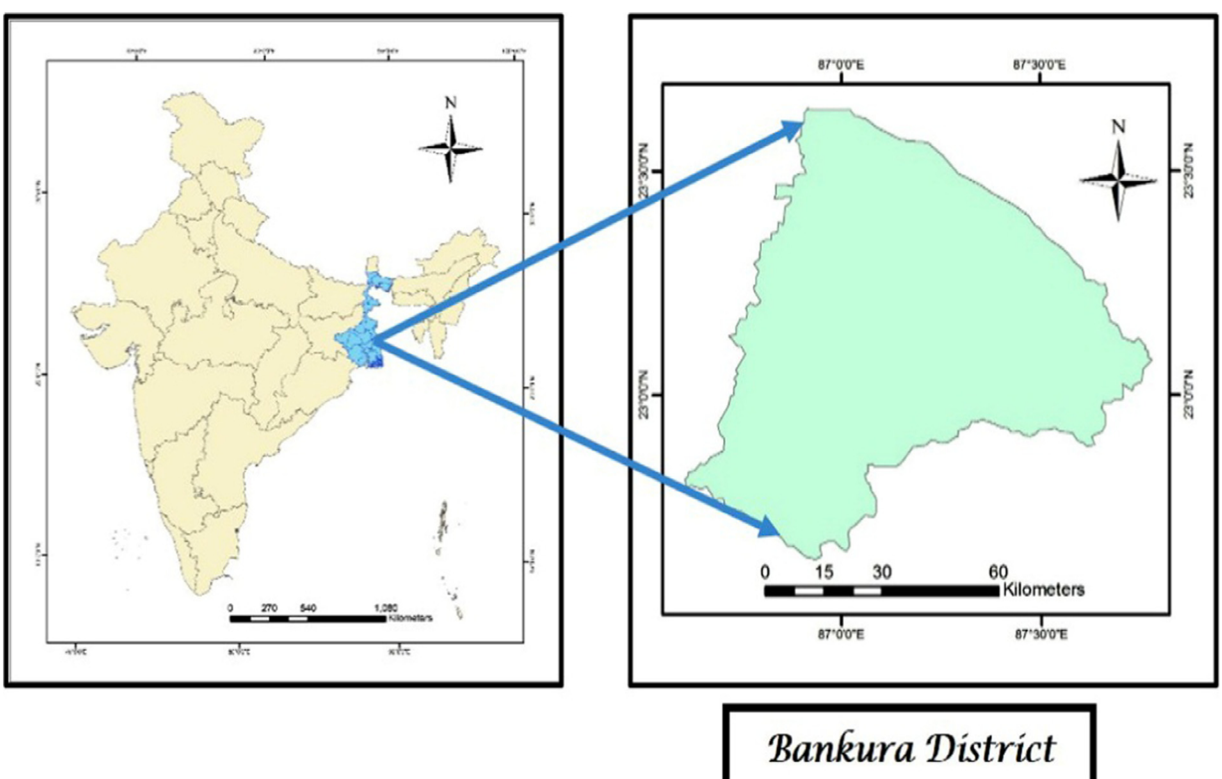

Fig. 1. Study area of interest.