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Elevated blood pressure and household solid fuel use in premenopausal women: Analysis of 12 Demographic and Health Surveys (DHS) from 10 countries

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ABSTRACT

Background: Approximately three billion people are exposed to household air pollution (HAP) from solid fuel cookstoves. Studies from single settings have linked HAP with elevated blood pressure (BP), but no evidence exists from multi-country analyses.
Objectives: Using nationally representative and internationally comparable data, we examined the association between solid fuel use and BP in 77,605 largely premenopausal women (aged 15–49) from ten resource-poor countries.
Methods: We obtained data on systolic and diastolic BP, self-reported primary cooking fuel, health and socio-demographic characteristics from 12 Demographic and Health Surveys conducted in Albania, Armenia, Azerbaijan, Bangladesh, Benin, Ghana, Kyrgyzstan, Lesotho, Namibia, and Peru. We estimated associations between history of fuel use [solid fuel (coal or biomass) versus clean fuel (electricity or gas)] with systolic and diastolic BP and hypertension using a meta-analytical approach.
Results: Overall, the country-level mean systolic and diastolic BP were 117 (range: 111–127) and 74 (71–83) mmHg, respectively. The country-level mean age of the women was 30.8 years (range: 28.4–32.9). The prevalence of solid fuel use was 46.0% (range: 4.1–95.8). In adjusted, pooled analyses, primary use of solid fuel was associated with 0.58 mmHg higher systolic BP (95% CI: 0.23, 0.93) as compared to primary use of clean fuel. The pooled estimates for diastolic BP and pulse pressure were also positive, but the confidence intervals contained zero. The pooled odds of hypertension was [OR = 1.07 (95% CI: 0.99, 1.16)], an effect that was driven by rural participants for whom solid fuel use was associated with a 16% greater odds of hypertension [OR = 1.16 (95% CI: 1.01, 1.35)].
Conclusions: Cooking with solid fuels was associated with small increases in BP and odds of hypertension. Use of cleaner fuels like gas or electricity may reduce cardiovascular risk in developing countries, particularly among rural residents.

1. Introduction

An estimated three billion people worldwide are exposed to household air pollution (HAP) from cooking with solid fuels, including wood, charcoal, coal, dung, and crop residues (Bonjour et al., 2013). The share of households cooking with solid fuel is more than two-thirds in many South Asian and sub-Saharan African countries (World Health Organization, 2016). Nearly all of the 2.6 million estimated premature deaths attributed to HAP exposure occur in low- and middle-income countries, making HAP an important environmental contributor to ill health in resource-poor countries (World Health Organization, 2012; Abajobir et al., 2017).

Considerable evidence supports associations between HAP and respiratory illnesses and deaths in adults and children (World Health

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Organization, 2012), but there is little direct evidence of its association with cardiovascular events (CVD) or mortality, with only four studies that have so far examined this association (Alam et al., 2012; Lee et al., 2012; Mitter et al., 2016; Abtahi et al., 2017). A number of studies, including population-based, measurement, and intervention studies in Latin America, China, and India, have shown association between solid fuel use and blood pressure (BP) (Lee et al., 2012; McCracken et al., 2007; Baumgartner et al., 2011; Burroughs Pena et al., 2015; Alexander et al., 2015; Clark et al., 2013; Norris et al., 2016; Yan et al., 2016), which is itself an important risk factor for CVD (Danaei et al., 2014). While such accumulating data are compelling, coherence would be strengthened by inclusion of studies that examine history of solid fuel use and BP relationships across diverse populations and multiple countries. Additionally, no cross-country data exist on the use of solid fuel and BP relationships among young women who are likely to be amongst the most highly exposed due to daily cooking with solid fuels.

In this paper, we report the association between self-reported solid fuel use (a proxy for HAP exposure) and BP and hypertension in 77,605 largely young and premenopausal women (aged 15–49 years) from ten resource-poor countries, using a nationally representative and internationally comparable data. In many resource-poor country settings, women in this age range are generally the ones most exposed to HAP due to their role in daily cooking with solid fuels.

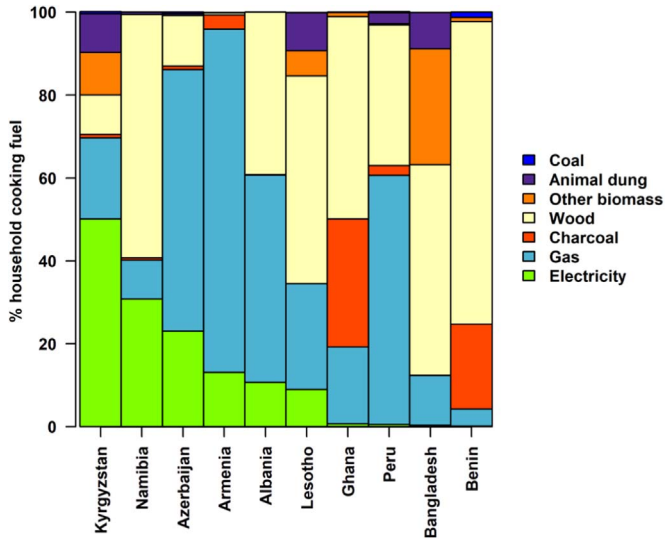

Fig. 1. Distributions of household cooking fuel types by country (percent households). Each bar represents one country, with countries ordered by decreasing prevalence of electricity use.

2. Methods

2.1. Data sources and study population

We obtained data from 12 standard Demographic and Health Surveys (DHS) conducted in ten countries: Albania, Armenia, Azerbaijan, Bangladesh, Benin, Ghana, Kyrgyzstan, Lesotho, Namibia, and Peru. The DHS are internationally comparable household surveys that collect information on demographic, socioeconomic and health-related variables among nationally representative samples of households in developing countries. The survey design follows a two-stage cluster random sampling procedure, randomly selecting households with women in a representative set of local enumeration areas drawn from national sampling frames. After normalization in each country, the surveys are designed to be representative both of urban and rural areas, and of geographical regions. Details of the DHS sampling design and strategies are described elsewhere (Corsi et al., 2012).

Each standard DHS includes questions related to household structure and wealth, maternal education, and employment. In the household survey, women also reported on their household's primary cooking fuel as either electricity, liquefied petroleum gas (LPG), natural gas/biogas, kerosene, or one of six solid fuels (coal, charcoal, wood, straw/shrubs/grass, agricultural crop, or animal dung). In addition to the traditional household variables (i.e., household structure and wealth, urban/rural living, maternal education, employment, and fertility), some surveys also collected individual-level anthropometric and biomarker data relating to a number of health conditions, including systolic and diastolic BP in women aged 15–49 years. In these surveys, the trained interviewers who conducted the interviews with consenting women also collected three BP measurements using fully automatic digital BP measuring devices (mostly Omron and LifeSource devices) with automatic upper-arm inflation and pressure release. The average of the last two measurements was used to estimate participant's systolic and diastolic BP. Measurements followed a standardized protocol across countries.

BP data was not routinely collected as part of the standard DHS, but has been added as a special module in selected countries. Currently, BP (and its related covariates) data was only collected for women aged 15–49 years. Thus for this study, we pooled and included all 12 surveys where such data were available. Each of the ten countries included in this analysis had one round of the surveys with records on BP and household cooking fuel, except Lesotho and Peru, which had two rounds each, and were combined into a single country-specific dataset. The data in this analysis were collected between 2005 and 2014 across the ten index countries.

2.2. Data management and statistical analysis

After excluding households that relied primarily on kerosene for cooking (< 1%), we calculated the distribution of primary cooking fuel, namely coal, animal dung, wood, charcoal, other biomass (agriculture/crop products, shrub/grass), liquefied petroleum gas (LPG), and electricity for each country (Fig. 1). The primary exposure variable of interest and our proxy indicator for HAP was household use of solid fuels (exposed group) for cooking. Solid fuels used by households in this analysis included coal, charcoal, wood, animal dung, agriculture/crop products, and shrub/grass. Households using clean fuels (electricity or gas) as their primary cooking fuel served as the reference (unexposed) group. Our primary outcomes of interest were average systolic and diastolic BP, and hypertension, defined as an average systolic BP ≥ 140 mmHg, or an average diastolic BP ≥ 90 mmHg. Pulse pressure, a marker of arterial stiffness, calculated as the difference between systolic and diastolic BP (Safar et al., 2003, 2015), was also examined. There were a few unusual or implausible values in the individual average systolic and diastolic BP records: one woman in Armenia, whose average systolic BP was below 50 mmHg, and 4 women (from Azerbaijan, n = 1; Ghana, n = 2; and Namibia, n = 1) whose average diastolic BP fell below 35 mmHg. In addition there were a total of 69 (0.09%) women with pulse pressures of 5 mmHg or lower, or above 110 mmHg; these women were excluded in sensitivity analysis, but their exclusion had no impact on the final results.

In a meta-analytical approach, we first estimated country-specific associations of BP parameters with solid fuel utilization using the following linear mixed-effects model:

$$BP = \beta_0 + \beta_1(Cooking\ fuel) + \beta_2 X + \gamma + \varepsilon \quad (1)$$

where BP is systolic BP, diastolic BP, or pulse pressure (mmHg); Cooking fuel is binary indicator of subject's primary cooking fuel (clean fuel = 0, solid fuel = 1); X is a vector of individual level factors, including age (years; continuous), body mass index [(BMI) kg/m^2; continuous), ethnicity, education, occupation, wealth index, place of residence (urban, rural), and calendar month of interview; γ is the subject's region of residence (country's largest subnational geographical