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Effect of a clean stove intervention on inflammatory biomarkers in pregnant women in Ibadan, Nigeria: A randomized controlled study

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ABSTRACT

Background: Exposure to household air pollution (HAP) has been linked to systemic inflammation. We determined the impact of transition from traditional firewood/kerosene stove to bioethanol-burning stove on inflammatory biomarkers in pregnant Nigerian women.
Methods: Women ($n = 324$), cooking with kerosene/firewood, were recruited during their first trimester of pregnancy from June 2013–October 2015 and were randomly allocated to either control ($n = 162$) or intervention ($n = 162$) group using web-based randomization. Controls continued to use their own firewood/kerosene stove, while intervention participants received bioethanol CleanCook stoves. Serum concentrations of retinol-binding protein (RBP), malondialdehyde (MDA), tumor necrosis factor alpha (TNF)-α, interleukin (IL)-6, and IL-8 were measured by ELISA.
Results: After excluding 53 women (loss of follow-up, untimely biomarker assessments, incorrect dates of enrollment), data from 271 women were included in analysis. Mean (SD) change in RBP, MDA, TNF-α, IL-6, and IL-8 between baseline and third trimester was −2.16 (4.47), −19.6 (46.4), 3.72 (37.2), 0.51 (14.4), and 13.2 (197), respectively, in intervention and −2.25 (4.30), −24.6 (43.6), 7.17 (32.6), −1.79, (11.4), and 31.3 (296) in control groups. None of these changes differed significantly between the two treatment arms. However, changes from baseline in TNF-α levels were significantly different between intervention and control groups in subset of women ($n = 99$) using firewood before trial (−7.03 [32.9] vs. +12.4 [33.6]; 95% CI for group difference: −35.4 to −3.4, $p = 0.018$).
Conclusions: Decrease in TNF-α concentration from baseline to third trimesters in intervention group women could indicate reduced cardiovascular stress and prothrombotic effects from decreased HAP. Our findings suggest that ethanol-burning stoves may mitigate cardiovascular health risks.

1. Introduction

Nearly 3 billion people worldwide use biomass and coal for cooking and heating purposes (Organization WH, 2014). The use of poorly vented traditional and biomass stoves results in household air pollution (HAP) in many low- and middle-income countries (LMICs). HAP, the eighth leading contributor to overall global disease burden, is responsible for 2.9 million deaths annually and 85·6 million DALYs (Forouzanfar et al., 2015). Premature mortality related to air pollution in urban settings is projected to reach about 65% by 2050 (Lelieveld et al., 2015).

HAP threatens lives of the world's most vulnerable populations and contributes to environmental degradation (Brook et al., 2010). In some developing countries, particulate matter (PM) and carbon monoxide levels from incomplete combustion of biomass fuels for cooking are 20–100 times above World Health Organization (WHO) guideline limits and national standards (Burroughs Pena et al., 2015; Oluwole et al., 2013a). In Sub-Saharan Africa (SSA), biomass fuels are the primary

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source of energy used for cooking for 753 million people, which accounts for 80% of its population (IEA, 2015). In Nigeria, about 122 million people use biomass fuels for household energy needs (IEA, 2015). No other region in the world has such a large population relying on biomass fuels for cooking and household energy needs. Eighty percent of cardiovascular deaths worldwide occur in SSA and other LMICs (Organization WH, 2013). Nigeria is among 15 countries that account for most of the premature mortality linked to air pollution with 89 deaths per 100,000 (Lelieveld et al., 2015).

The greatest exposure burden to HAP in Nigeria is among women and children, as they typically assume the bulk of household cooking duties, and this can result in a multitude of detrimental health effects including respiratory, cardiovascular, and ocular damage, and increased susceptibility to infectious illnesses such as tuberculosis (Oluwole et al., 2013a; Pekkanen et al., 2002). However, these adverse health effects have not been studied in an integrated and scientifically rigorous manner.

Exposure to air pollution, especially $PM_{2.5}$, can trigger oxidative stress and systemic inflammation directly from pulmonary oxidative stress through inhalation of toxic pollutants (Brook et al., 2010). Hence, even though systemic inflammation is not generally associated with pregnancy in seemingly healthy women (Vitoratos et al., 2010), this process may be triggered by HAP exposure. Relative to the use of LPG stoves, regular cooking with biomass aggravates systemic inflammation and oxidative stress that may increase the risk of cardiovascular disease (CVD) (Dutta et al., 2012). Similar conditions in pregnant women could predispose them to increased CVD risk, a major cause of adverse pregnancy outcomes and maternal mortality (Moghbeli et al., 2008). Particulate matter has previously been found to induce interleukin-6 (IL-6), interleukin-8 (IL-8) and tumor necrosis factor (TNF)-alpha production (Delfino et al., 2009; Osornio-Vargas et al., 2003). Malondialdehyde (MDA), an indicator of oxidative stress, was also found to be elevated in rural populations exposed to HAP (Isik et al., 2005). HAP from burning of biomass fuel can be markedly reduced by clean cook stove interventions (Thomas et al., 2015), but residual levels of pollutants can remain high and can still pose significant health risks to household inhabitants (Oluwole et al., 2013a).

Clean cookstoves and fuels (i.e. high-efficiency and low emission) have been offered as a potential tool to reduce HAP exposure, improve health outcomes, and decrease greenhouse gas emissions and deforestation (Hanna et al., 2012). Though association between HAP and risk of developing CVD is well established, there are few studies that have investigated the effect of HAP intervention (viz., clean cook stoves) on attenuation of short and long-term CVD risks (Clark et al., 2013; McCracken et al., 2011). Prior studies have reported improved lung function (Heinzerling et al., 2016), decreased frequency of respiratory (e.g. cough, phlegm, wheeze, chest tightness), non-respiratory (e.g. eye discomfort, headache, backache) (Diaz et al., 2008) symptoms in intervention groups using improved cook stoves (Accinelli et al., 2014).

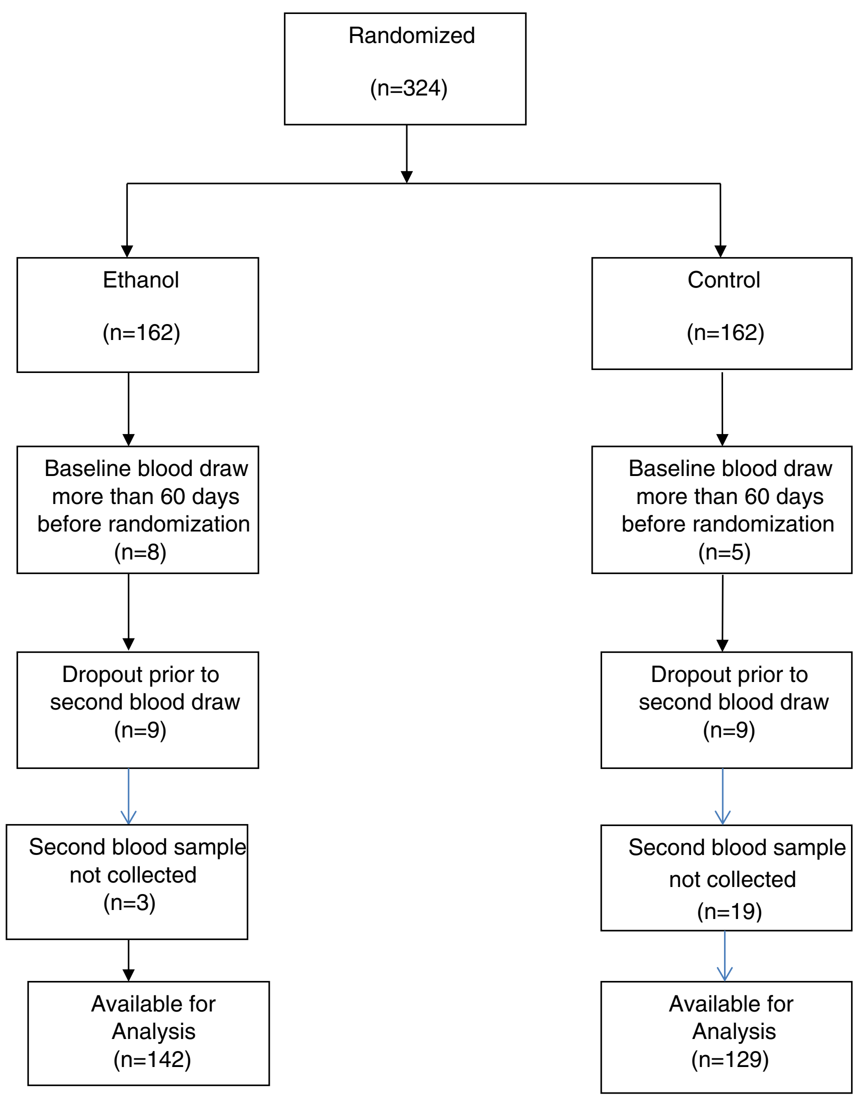

Fig. 1. Trial Profile.

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