Investigation of acute pulmonary deficits associated with biomass fuel cookstove emissions in rural Bangladesh

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Motivation
The burning of biomass fuels including wood, charcoal, and animal dung in open fire stoves results in incomplete combustion, leading to the emission of particulate matter (PM), carbon monoxide, hydrocarbons, oxygenated organics, free radicals, and chlorinated organics. The use of solid biomass fuels in cookstoves has been associated with chronic health impacts that disproportionately affect women worldwide. It is estimated that about 50% of deaths resulting from chronic obstructive pulmonary disorder (COPD) can be attributed to chronic exposure to combustion biomass fuel.

Objectives
• Measure pulmonary function using spirometry before and during cooking in consented women between the ages of 18-65 who are exposed to cookstove pollutants
• Measure PM2.5 exposure from biomass cookstoves with active sampling monitors
• Determine changes in pulmonary function during smoke exposure, and whether acute changes in lung function are correlated with 3-minute maximum and 10-minute maximum PM2.5 emitted by biomass-burning cookstoves

Approach
Survey. For each household, a survey was conducted with the assistance of a Bengali translator. The survey included information such as family demographics, education, cooking habits, pulmonary health, overall health, and smoking habits to account for confounding factors.

Spirometry. Lung function was tested using the Pneum FX Spirometer (Cosmed USA, Chicago, IL). Specifically, lung function measurements of forced expiratory volume in one second (FEV1), forced vital capacity (FVC), FEV1 over FVC ratio (“Tiffeneau-Pinelli Index”) and peak expiratory flow (PEF) were compared. Following a training bout to ensure reproducibility of measurements, subjects were first tested while not cooking, and then tested a second time while cooking. Proportion of predicted FVC and FEV1 measurements were calculated, and adjusted for age, height, gender, and ethnicity.

Air Quality measurements. For each participant, a DustTrack 8520 aerosol monitor (TSI Inc., Shoreview, MN) was placed near the cookstove both (1) during the burning of biomass fuels and (2) while cookstoves were not in use, in order to obtain baseline measurements. Individual exposure metrics were calculated as 3-minute maximum and 10-minute maximum PM2.5 (μg/m3) minus 10-minute average baseline.

Results
Research Participant Demographics and Cooking Characteristics

Pre-Post Cooking Pulmonary Function

Symptoms Encountered During Cooking

Survey
For each household, a survey was conducted with the assistance of a Bengali translator. The survey included information such as family demographics, education, cooking habits, pulmonary health, overall health, and smoking habits to account for confounding factors.

Discussion and Conclusions
• Baseline-adjusted 3- and 10-minute maximum PM2.5 measurements obtained during cooking were significantly associated with instantaneous decrements in average FEV1, FVC, and FEV1/FVC ratio for both measured and predicted pulmonary function parameters (based on age, height, gender, and ethnicity) among individuals participating in this study. This finding demonstrates that instantaneous changes in pulmonary function are likely occurring during cooking with biomass fuels.
• In this pilot study, several cases were observed in which women who were 40 years old and older had been cooking for more than 25 years exhibited symptoms of COPD. Additionally, two subjects demonstrated normal spirometry before cooking, but displayed possible mild restriction during smoke exposure, indicating irritation and possibly early signs of obstructive disorder.
• Significant ‘pre-cooking’ pulmonary function changes at the study population level were not observed. Cultural and language barriers were also factors that decreased the efficiency and confidence of the pilot study.
• We are hopeful that the Duwali Medical Foundation, in collaboration with UNR medical students, can hold pulmonary health clinics for women and children. Additionally, education sessions for women about the importance of keeping children out of cooking areas and suggestions on methods to limit smoke inhalation while cooking would be cost efficient ways in which to improve the lives of women living in rural Bangladesh.

References and Funding
1Naeher, L. P. et al. (2007). Inhalation Toxicology 19(1-4): 67-10
2Lim, S. S. et al. (2013). The Lancet 380 (9859): 2224-2260

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