Analysis of Personal Exposure Assessment Techniques for Use in Ghana Intervention

Autumn Bordner[1], Steve Chillrud[2], Pat Kinney[3], Darby Jack[3], Madhavi Parekh[3], Grace Manu[4], K.P. Asante[4]

[1]Columbia College, Columbia University, New York, NY, [2]Lamont Doherty Earth Observatory, Columbia University, New York, NY, [3]The Mailman School of Public Health, Columbia University, New York, NY, [4] Kintampo Health Research Center, Kintampo, Ghana

Roughly 3 million people per year die prematurely from illness attributable to indoor air pollution and nearly 50% of pneumonia deaths among children under five are attributed to indoor air pollution from cooking or heating with biomass fuels. Over the past several years there have been a number of initiatives proposed to implement cleaner cook stoves in developing regions such as Ghana. In order to increase effectiveness of intervention efforts, it is critical to understand what level of air pollution reduction is necessary to achieve appreciable health improvements. Seeking to gain such understanding, Columbia University is partnering with the Kintampo Health Research Center to launch the first randomized cook stove intervention study in Africa. The pollutant of interest in this study is particulate matter less than 2.5 microns ($PM_{2.5).}$ $PM_{2.5}$ is believed to be the best proxy for smoke exposure from cook stoves, however monitoring $PM_{2.5}$ is difficult and expensive. Indeed, the upcoming randomized cook stove intervention study has funding to monitor $PM_{2.5}$ during only 1 of 7planned monitoring sessions. Therefore, a method to approximate $PM_{2.5}$ exposure is needed. Typically approximating $PM_{2.5}$ personal exposure involves a proxy method in which carbon monoxide (CO) and $PM_{2.5}$ exposures are measured in a kitchen or subset of subjects and personal $PM_{2.5}$ exposure is predicted using the correlative relationship between CO and $PM_{2.5}$. Personal CO exposure is easier and cheaper to measure, making it a much more practical method of assessing personal exposure to $PM_{2.5}$. However, recent findings have thrown this proxy method into dispute. Thus it is crucial to evaluate the tenacity of this method before launching the randomized cook stove intervention study in Ghana. Data from pilot studies in Ghana are used to test the validity of this method. Specifically, the relationship between CO and $PM_{2.5}$ was analyzed from data collected during controlled cooking sessions in which 3 cooks prepared a standard local meal repeatedly (n=15) and rotated through 3 different stove types (3 stone fire, Stove Tec, LPG). Furthermore data were analyzed from personal deployments in villages over 3 or 6 days. The relationship was analyzed on several temporal scales (minute, cooking session, 24 hour) in order to discern whether the degree of predictive ability varied with temporal resolution. On the session (ca. half-hour) time scale, a robust predictive relationship between CO and $PM_{2.5}$ is found in the case of the 3 stone fire. A less robust but still significant predictive relationship is found between CO and $PM_{2.5}$ in the case of the LPG stove. No predictive relationship is found between CO and $PM_{2.5}$ exposure data from the Stove Tec stove or ambient air. A robust predictive relationship is found across all stove types, though this relationship is dominated by the3 stone fire signal. CO data from the villages on a 24 hour time scale (n = 24) appear to be poorly predictive of $PM_{2.5}$ exposure but more data from the villages are being analyzed. Identifying which type of stove is generating the emissions is being evaluated through temperature loggers.