THE CONTRIBUTION OF HOUSEHOLD HEATING TO AMBIENT PM$_{2.5}$ IN PERI-URBAN BEIJING AND ITS POPULATION EXPOSURE IMPLICATIONS

By

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EXECUTIVE SUMMARY

Background: Cooking and space heating with biomass and coal is associated with significant global health burdens. Ambient air pollution (AAP) is estimated to be associated with one million premature deaths in China and is regarded as a major environmental problem. Household air pollution (HAP) and AAP due to emissions resulting from cooking with biomass and coal are estimated to cause about one million premature deaths yearly in China. The contribution of space heating to HAP and AAP is not well studied, however, even though heating with biomass and coal is common and the large proportion of pollution is emitted to atmosphere through chimney.

Method: I analyzed the data collected from June 2012 to March 2013 on 33 households at Erhezhuang (EHZ) village in peri-urban China, about 40km away from Beijing. Based on Stove Usage Monitors (SUMS) data, ambient air $PM_{2.5}$ data, meteorological station data and household survey data collected by Zimmermann, I estimated hourly $PM_{2.5}$ emissions and developed three time-series models to explore the relationship between $PM_{2.5}$ emissions per hour (EPH), hourly ambient $PM_{2.5}$ concentrations and to assess the contribution of household emissions to AAP. I further built a one-compartment model on pollutant emitted from household space heating in rural North China Plain (NCP). Intake fraction (iF) of air pollution and population average $PM_{2.5}$ exposures from this source were estimated based on iF and fuel use activities.

Results: Between Jan. 9th and Mar. 10th, 2013, the average ambient $PM_{2.5}$ concentration was 139 ± 107 $\mu g/m^3$ (mean ± standard deviation), and average primary $PM_{2.5}$ EPH from household biomass and coal is 736 ± 38 g/hour at study site. Time series model indicated that one-hour lag $PM_{2.5}$ emissions from household solid fuel use provide statistically significant prediction of ambient air $PM_{2.5}$ concentrations, suggesting Granger causality of household emission to ambient air pollution. Household emissions resulting from solid fuel space heating on average contributes 7 $\mu g/m^3$ ambient $PM_{2.5}$ concentrations. iF of the pollutant emitted from household directly to atmosphere through chimney is in the range of 10^{-6} to 10^{-5}, indicating 9 $\mu g/m^3$ $PM_{2.5}$ average exposure for population living in rural NCP during winter heating season, after incorporating for population density and fuel use activities.

Discussion: Time series models suggest a significant contribution of household solid fuel combustion to AAP and health risks associate with AAP. With high population density, directly emitted pollutants originated from space heating shows a relative large iF and population average exposure of AAP. With currently large amount of coal use for household space heating and large household heating emissions in NCP, China, AAP resulting from household heating in NCP not negligible and is associated with substantial health burden. This implies that in order to reduce health burden from AAP in China, more attentions should be paid to reduce or even eliminate household coal use in rural China by substituting cleaner fuels.