IMPACT EVALUATION OF INYENYERI RWANDA

Exposure to Household Air Pollution (R2-2016)

HAP and exposure

Despite the enormous health, welfare, and environmental consequences of HAP, there are surprisingly few initiatives that present realistic opportunities for large-scale adoption of cleaner cooking energy systems. Inyenyeri seeks to mitigate exposure to HAP by providing a cleaner cooking energy system that burns biomass more efficiently than the baseline cooking system.

The proximate factors hypothesized to influence exposure to HAP include:

- Stove design;
- Fuel type, quantity, and quality; and
- Ventilation.

Research Question

Does adoption and sustained use of the Inyenyeri household energy system reduce personal exposure to carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), and polycyclic aromatic hydrocarbons (PAHs) for cooks?

In this study we simultaneously test the effect of stove type, fuel type, quantity, and quality, and ventilation (proximate factors) hypothesized to affect personal exposure to HAP. In addition to these proximate determinants, we leverage a rich set of socioeconomic and demographic data to examine the role of underlying causes of personal exposure to HAP (e.g., poverty, cook's age and experience, education, awareness about HAP and other variables.

For a sub-sample of households (N=180) nested within the broader sample of 1,500 we undertake repeated measures (5) of personal exposure to CO, $PM_{2.5}$, PAHs.

Measuring exposure

CO measurements were carried out with a CO data logger (Model EL-USB-CO, Lascar Electronics) (Fig. 1). The data logger measures CO concentration between 0 and 1000 ppm at 1 minute intervals. Ability to monitor temporal variations in CO levels for the primary cook is important for relating exposure to daily activities. After completion of the 24-hour measurements, the data are downloaded and stored using the manufacturer's software.

Figure 1: EL-USB-CO, Lascar Monitor

$PM_{2.5}$ concentrations in the cook's breathing zone are determined using a personal environmental monitor loaded with a filter and connected to an air sampling pump operating at 2 liters/minute. Filters are weighed pre- and post-sampling using a calibrated microbalance. $PM_{2.5}$ is measured gravimetrically, allowing us to estimate $PM_{2.5}$ concentration in mg/m^{-3}.

PAH concentrations are determined using a polyurethane foam (PUF) sampler containing PUF, XAD2 sorbent, and a filter connected to an air sampling pump operating at 2 liters/minute. We determine the concentration of 16 PAHs currently on the US Environmental Protection Agencies priority list using GC-MS analysis. These PAHs represent the most prominently observed PAHs in the gaseous and particle phases emitted from burning cooking fuels.

Figure 2: Personal exposure monitoring

Carbon monoxide and particulate matter 2.5 personal exposures

CO exposure fluctuates during the day (Fig. 3). Between 12 AM and 6 AM exposures are very low. Average hourly concentrations are highest during cooking times, primarily between 11 AM and 8 PM when most cooked meals are prepared. When we consider average hourly concentrations we find that they exceed WHO guidelines for several households (those falling above the red line). For a sample of 150 households we plot 24-hour averages of $PM_{2.5}$ and CO (Fig. 4). The plot reveals that almost all cooks sampled have $PM_{2.5}$ exposures that exceed WHO guidelines (red and yellow circles). We also observe that 26% of cooks experience 24-hour exposures to both $PM_{2.5}$ and CO that exceed WHO guidelines (red circles). Our expectation is that households that adopt the Inyenyeri cleaner cooking system may experience reductions in personal exposure.

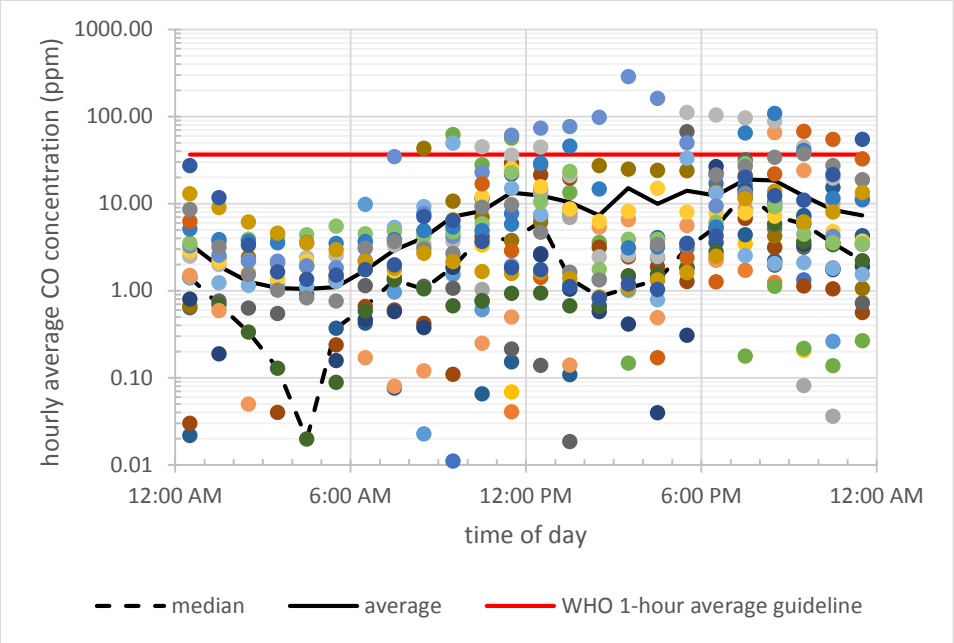

Figure 3: Hourly average CO concentration by time of day (N=23 cooks)

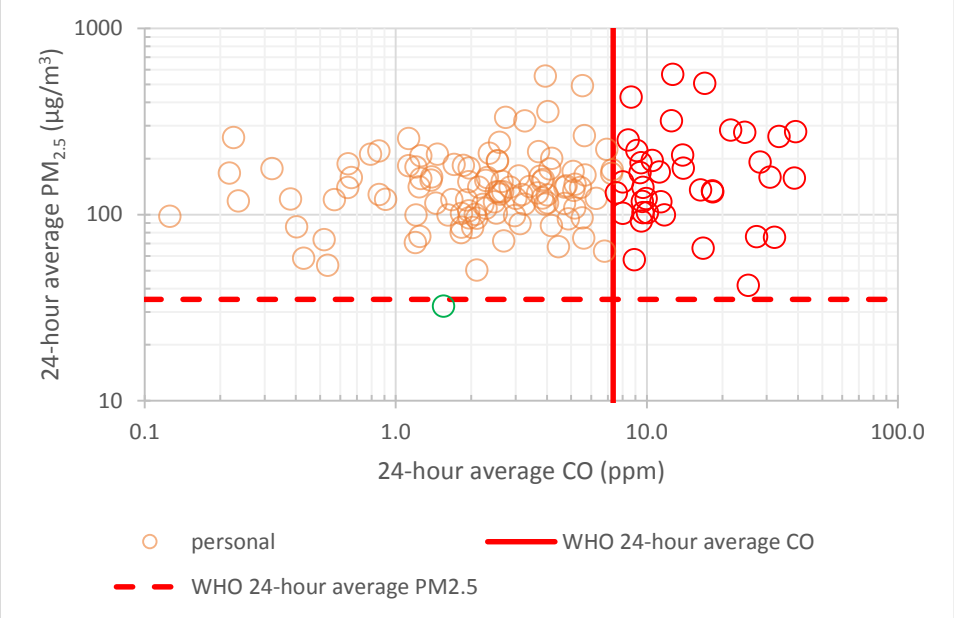

Figure 4: 24-hour exposures to $PM_{2.5}$ and CO (N=150 cooks)

PAH preliminary results

- Levels of both gaseous and particulate PAHs are much higher than recorded recommendations
- Material used to light the stove (plastic or sticks/wood) does not seem to effect emissions
- Most PAHs were in the gaseous phase, but higher molecular weight 4 and 5 ring PAHs (probable carcinogens) were seen in relative abundance in the particle phase

Next steps

Our next steps are to continue with data processing (CO and PAHs) and to relate CO, $PM_{2.5}$ and PAH exposures to cooking environments including considering the type of stoves, fuel, and ventilation setting where people are doing most of their cooking. We will be collecting our second round of data in May/June/July of 2016.

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For more information contact Pam Jagger
pjagger@unc.edu http://fuel.web.unc.edu