Webinar: ASHES Science to Achieve Results (STAR) Webinar Series #2: Experimental Interventions to Facilitate Clean Cookstove Adoption, Promote Clean Indoor Air, and Mitigate Climate Change

Date/Time: February 24, 2021, 8:00-9:30 Mountain Standard Time

Unasked/answered Panelist Questions

1. For LPG and climate, how do you account for the R & D, refinement, transportation, and delivery of carbon footprints? Also do you address the local job and economic issues for the local solid fuel entrepreneurs that are having their jobs replaced?

Rob B: though it depends on the source of LPG, "upstream" emissions for LPG derived from conventional fossil fuels is relatively low compared to emissions from end use. This source estimates that it is around 10% of total life cycle emissions (see https://auto-gas.net/wp-content/uploads/2019/11/2017-WLPGA-Literature-Review.pdf)

The impacts on employment for wood suppliers was not considered in this study. 95% of the study HHs in Kullu and 85% in Koppal collected all of their fuelwood, so even if everyone shifted to exclusive LPG use, the livelihood impacts on wood suppliers would have been minimal.

2. For exclusive use of LPG, do you think demand from rural households could be higher than for urban households because of the availability of prepared foods from restaurants and street vendors in urban areas?

Abhishek K: We did not collect any data specifically to reliably answer this question.

3. Given that you were only able to measure kitchen PM2.5 concentrations (and not personal exposures), do you think the LPG stoves needed less 'tending' and so cooks were less likely to spend time close to the emission source - and so their personal exposure would be much lower?

Andy G: I agree that stove technology will likely interact with cook activity, and will modify the linkage between stationary kitchen and personal PM2.5 exposures. I can't say whether or not personal exposure will be 'much lower', but do agree that it would likely be lower. Personal exposure depends on so many factors that I'd be hesitant to speculate the degree of this difference.

4. Can you comment on the effectiveness of chimneys attached directly to stoves versus hoods over stoves (or TSFs) with chimneys?

Andy G: The household chimneys appeared to be at least more consistently effective than stove-attached chimneys, which worked well in HP for the 'improved chimney' stove (Himanshu Tandoor; HT) but poorly for the traditional Tandoor (TT). For example, if you see the slide entitled 'IAQ Sum-up' you'll see that HT had the lowest mean/median concentration but the TT had mean and median concentrations higher than houses without chimney stoves in HP. The KA household chimney households had a ~50% reduction relative to households without chimneys using TSFs. Based on this, effectiveness is HT >

household chimney > TT and a built-in chimney is probably better than a poorly functioning chimney stove but maybe not quite as good as a well-functioning chimney stove. Emission factors for the different stoves (TSF, TT, HT) were not consistently different, so we can generally attribute this variation to ventilation performance of these different options.

5. Were people offered biomass pellets and gasifying stoves?

Rob B: We included one gasifier stove (TERI's model), but not pellets. We couldn't deal with the logistics of acquiring and supplying pellets to the communities. Plus, at that time, there were no pellet stove projects active in India that we knew of (Oorja had already come and gone without much success -- see https://doi.org/10.1016/j.esd.2014.01.002).

6. Could there be a factor of smoke still hanging in the kitchen air from open fire use, and after the clean stove still impacting the PM measurements until all is ventilated out in perhaps a couple of months or more?

Rob B: Andy could probably answer this best, but I'd respond by saying that PM doesn't generally stick around for more than a couple hours, certainly not for days or months. The time that a smoky room takes to clear out depends on ventilation. We estimated air exchange rates, which is a measure of ventilation, based on decays of observed PM concentrations after cooking events and found 7-8 exchanges per hour in Koppal and 10-12 in Kullu. Both are much higher than typical homes in the US or EU. After 3 air exchanges (e.g. a half-hour in Koppal or 15 minutes in Kullu), emitted concentrations will have decayed to ~5% of their original peak values on their way to background levels. Of course, if background levels are high, or emissions continue for a long time or if a neighbor is cooking at different times, this will affect how indoor concentrations decay over time.

7. Are you planning to publish an improved model based on this and if so when might this be?

Andy G: We continue to work on the model-measurement comparison element of this project, and will certainly publish a paper on it. It may result in an improved model, but at the very least will point out some factors moderating measurement-model agreement that might contribute to later model developments.

8. What are your hypotheses on why families revert back to biomass rather than use LPG?

Rob B and Abhishek K: There are many reasons why HHs continue to use wood after obtaining access to LPG:

- *Cost- LPG is new, they invest, and then, considering all other expenses, decide that spending money on LPG is simply not worth it. Ultimately, the end product is hot food whether cooked with LPG or firewood. The process is better (less smoke, less time, less effort) but the end result is the same whether they buy LPG or gather free firewood. In contrast, there are many paid services which provide unique end-product/ service which have no free alternative. If you want it, you have to pay for it- like cell phone*

- *They may prefer wood fires for certain foods -- a common example is roti and other flatbreads, which people like to place in an open fire*
- *It may be inconvenient to travel to a distributor to refill an empty cylinder*
- *People may find cooking exclusively with LPG is too costly even with the government subsidy*
- *People may consider LPG inappropriate for certain tasks - for example heating bath water or cooking food for livestock*
- *They may value wood or dung for some ritualized cooking practices such as heating milk for babies, preparing foods for pregnant women, etc.*
- *Some people consider the kitchen smoke to protect them from insects.*

9. How were the cost subsidy amounts determined?

Rob B: We didn't mention this during the seminar because of time constraints. Prior to the main intervention, we did a set of scoping exercises in nearby communities, which involved simple auctions and experiments to determine people's willingness-to-pay. This led us to believe that most families could afford the stoves at ~75% discount.

10. Is there any analogous research that includes data on solar cooking?

Rob B: I'm not aware of any, but you could contact Caitlyn Hughes at Solar Cookers International <caitlyn.hughes@solarcookers.org> to inquire about research into solar cookers.

11. Do you find that the EF goes down with stoves that have a chimney?

Andy: This is explored in detail in Islam et al., 2021. In brief, not really. The improved chimney stove (Himanshu Tandoor) did have a lower PM emission factor in some cases, but not consistently.

12. Could the survey biases have been reduced by administering more robust questionnaires and training of interviewers to bring out the truth (psychological push)?

Abhishek K: There is little guidance in literature on how to reduce survey biases if 1) respondent cannot self-administer questionnaire & 2) there is no privacy, as curious bystanders crowd around when outsiders visit home & 3) surveyors/ local partner institutions are associated with a certain image: pro-poor, pro-environment. The clean cooking community needs to take up this issue seriously on an urgent basis.

13. Can you talk a bit about the fact that tiers were previously developed based on emissions in light of your findings that show the importance of air-exchange rates and kitchen volume differences (that I typically think of as impacting concentrations) in the modeled vs measured concentrations? In other words, how does the difference between emissions and area concentrations come into play with these modeled vs measured comparisons?

Andy G: The point of our modeling exercise was to take all of the details we have from these households – emission factors, fuel use, dimensions and air exchange rates – and see what the model predicts versus

our in-home measurements. This is the same way the model is normally used, but with inputs specific to the household so reducing several sources of variability. So, if the model was representing our point measurements (and if emissions were well-mixed as assumed in the model), we'd see general agreement. That we saw such a large divergence (model overestimate in most cases) suggests that the model is overly conservative. Since this model framework was used to develop the Tiers (health guidelines informed target concentrations and the model was used to estimate the emissions required to meet concentration targets), this means that the Tiers are probably overly conservative (ie. Emissions could actually be higher than the tier limits to meet the corresponding concentration target). This is the 'better' way to be wrong, as it's conservative, but still also means that emission targets may be a bit too stringent. Of course, the bigger challenge is actually ensuring that the clean stove gets used universally as any continued use of a traditional stove will dominate overall emissions and exposure.

14. You mentioned that PM2.5 are vertically stratified. Where did you place the monitor that measured PM2.5 concentration? How confident you are that this measurement reflects the average concentration in the kitchen? The box model predicts the average kitchen concentration so we would need a measurement of the average kitchen concentration as well to compare the two, no?

Andy G: We know emissions can stratify vertically and there are some measurements of this in other settings. We followed the general guideline (http://berkeleyair.com/wp-content/publications/guidelines-for-instrument-placement.pdf) for placing HAP monitors, so they were ~1.2 m above the stove top and approximately 1m horizontally from the stove. The location for monitoring was selected as it should roughly reflect a cook's location during cooking. If emissions were actually well mixed, measurement location wouldn't matter, but our model/measurement comparisons suggest that this is likely not the case, and measurements reflect average kitchen concentrations. The model treats the room as a single compartment, so the most direct comparison would be a spatial average, but that isn't necessarily what is most relevant for exposure (e.g., if smoke accumulates well above head level, it's not contributing directly to exposure. Therefore, a 'near-stove' concentration is likely more relevant to exposure-based risk assessment than an actual kitchen average. Since the model is used in this manner (exposure-based risk assessment), it's more important to find a model form that better represents exposure than full-room averages. However, better understanding of exposure and how it varies spatially would definitely help in this.

EPA Agreement Number: RD #83543801

Title: Quantifying the climate, air quality and health benefits of improved cookstoves: An integrated laboratory, field and modeling study

Academic Publications:

1. Singh, D., S. Pachauri and H. Zerriffi (2017). "Environmental payoffs of LPG cooking in India." Environmental Research Letters 12(11): 115003 https://iopscience.iop.org/article/10.1088/1748-9326/aa909d/meta
2. Singh, D., T. Aung and H. Zerriffi (2018). "Resource Collection Polygons: A spatial analysis of woodfuel collection patterns." Energy for Sustainable Development 45: 150-158 https://www.sciencedirect.com/science/article/pii/S0973082617313960
3. Huang, Y., N. Unger, T. Storelvmo, K. Harper, Y. Zheng and C. Heyes (2018). "Global radiative effects of solid fuel cookstove aerosol emissions." Atmospheric Chemistry and Physics 18(8):5219-5233 https://acp.copernicus.org/articles/18/5219/2018/
4. Jagadish, A. and P. Dwivedi (2018). "In the hearth, on the mind: Cultural consensus on fuelwood and cookstoves in the middle Himalayas of India." Energy Research & Social Science 37 (Supplement C): 44-51 https://www.sciencedirect.com/science/article/abs/pii/S2214629617302980
5. Jagadish, A. and P. Dwivedi (2019). "Deconstructing networks, unearthing consensus: Diffusion of "cleaner" cookstoves in rural Himalayas of India." Energy, Sustainability and Society 9(1):5 https://link.springer.com/article/10.1186/s13705-019-0188-1
6. Jagadish, A., P. Dwivedi, K. D. McEntire and M. Chandar (2019). "Agent-based modeling of "cleaner" cookstove adoption and woodfuel use: An integrative empirical approach." Forest Policy and Economics 106: 101972 https://www.sciencedirect.com/science/article/abs/pii/S1389934118304192
7. Kar, A., S. Pachauri, R. Bailis and H. Zerriffi (2019). "Using sales data to assess cooking gas adoption and the impact of India's Ujjwala programme in rural Karnataka." Nature Energy 4(9):806-814 https://www.nature.com/articles/s41560-019-0429-8
8. Menghwani, V., H. Zerriffi, P. Dwivedi, J. D. Marshall, A. Grieshop and R. Bailis (2019). "Determinants of Cookstoves and Fuel Choice Among Rural Households in India." EcoHealth 16(1):21-60 https://link.springer.com/article/10.1007/s10393-018-1389-3
9. Kar, A., Singh, D., Pachauri, S. , Bailis, R., & Zerriffi, H. (2019), Ujjwala at 6 crores: Impact on Cooking Energy Transition and Climate Change. In: The Ujjwala Saga - Unending Happiness & Health. pp. 16-21 Ministry of Petroleum and Natural Gas, Government of India, http://pure.iiasa.ac.at/id/eprint/15741/
10. Kar, A., Pachauri, S., Bailis, R. et al. (2020) Capital cost subsidies through India's Ujjwala cooking gas programme promote rapid adoption of liquefied petroleum gas but not regular use. Nat Energy 5, 125–126. https://doi.org/10.1038/s41560-019-0536-6
11. Islam, M. R. Wathore, et al, (2021). "In-use emissions from biomass and LPG stoves measured during a large, multi-year cookstove intervention study in rural India" Science of The Total Environment 758, 143698 https://doi.org/10.1016/j.scitotenv.2020.143698

12. Singh, D., H. Zerriffi, R. Bailis and V. LeMay (2021). "Forest, Farms and Fuelwood: Measuring changes in fuelwood collection and consumption behavior from a clean cooking intervention."Energy for Sustainable Development (in Press).
13. Islam M., R. Wathore, et al, (2021). “Assessing the effects on indoor air quality of a large, multi-year cookstove randomized control trial in rural India” (submitted to ES&T)
14. Kar, A., Bailis, R., Brauer, M., Zerriffi, H., 2020 The risk of survey bias in self-reports vs. actual consumption of clean cooking fuels. World Development Perspectives 18, 100199 (1-6).
15. Kar, A., Pachauri, S., Bailis, R., Zerriffi, H., 2019. Ujjwala 2.0 Needs to Also Include Non-Ujjwala Rural LPG Consumers. In Harish, S., Smith, K., 2019 eds., Ujjwala V2.0: What Should be Done Next? Policy Brief, CCAPC/2019/2, Collaborative Clean Air Policy Centre, New Delhi.

Op-eds

1. Kar, A., Zerriffi, H., 2017. Accelerating the blue-flame revolution in India. The New Indian Express, 20 October 2017.
2. Kar, A., Zerriffi, H., 2018. Pradhan Mantri Ujjwala Yojana: Smokeless kitchens are becoming a reality. In Financial Express, August 7, 2018.
3. Shreerupa, Kar, A., 2018. The NDA government’s Ujjwala scheme is not a failure. Hindustan Times, April 3, 2018.
4. Kar, A., Zerriffi, H., 2019. Ujjwala has fulfilled its original purpose now time to take it to the next level. In Swarajya, September 25, 2019.

Scientific & General Media Coverage of published papers

1. https://www.asianscientist.com/2019/08/in-the-lab/india-indoor-air-pollution-lpg-adoption/
2. https://**researchmatters**.in/news/pradhan-mantri-ujjwala-yojana-brightening-lives-rural-karnataka
3. https://www.**telegraphindia**.com/india/ujjwala-enrolment-and-refill-show-gap/cid/1694636 (Front Page)
4. https://www.**deccanherald**.com/national/new-study-questions-success-of-centres-lpg-scheme-747371.html (Front Page)
5. https://energy.**economictimes**.indiatimes.com/news/oil-and-gas/indias-ujjwala-scheme-provided-lpg-access-but-failed-to-promote-its-use-study/73580017
6. https://www.**moneylife**.in/article/pmuy-beneficiaries-use-just-23-lpg-cylinders-a-year-study/57688.html
7. https://www.**anandabazar**.com/business/question-on-centre-s-ujjwala-yojana-scheme-1.1100146
8. https://khabar.**ndtv**.com/news/india/pmuy-helped-lpg-cylinders-reach-homes-but-not-help-to-increase-usage-2169276