

Cover Essay

Changing Paradigms in Clean Cooking

The latest Comparative Risk Assessment of the Global Burden of Disease (GBD) estimates that household air pollution (HAP) from solid cooking fuels imposes the largest environmental health burden in the world among all risk factors examined (Lim et al. 2012). With about 4 million premature deaths annually from both the household exposures and the exposures downwind from household contribution to outdoor air pollution (secondhand cooksmoke), HAP is ranked fourth in the world among all the risk factors, even though only about 40% of the world is directly exposed, those in poor countries cooking with biomass or coal (Smith et al. 2014).

There will be changes in these estimates going forward, due to better evidence on relative risks of the current diseases associated with HAP [acute lower respiratory infection (pneumonia) (ALRI), chronic obstructive pulmonary disease (COPD), ischaemic heart disease (IHD), stroke, lung cancer, and cataracts], more accurate exposure estimates, and addition of new diseases for which evidence is suggestive but not yet convincing (e.g., TB, birth outcomes, and cognitive effects), but it seems that HAP has crossed a historical threshold. Regardless whether it is 4, 2, or 6 million premature deaths, HAP is clearly responsible for much ill health among, almost by definition, the least advantaged people in the world. It has joined the gorillas in the room like outdoor air pollution, high BMI, sodium intake, child underweight, and physical inactivity, in the global burden, although somewhat smaller than the three elephants: high blood pressure, alcohol, and smoking. Like all these others, it is not going away easily either in our risk estimates or on the ground.

The health impacts of HAP have been suspected for decades, and a few isolated studies occurred more than a half-century back (e.g., Padmavaty and Pathak 1959), but it has only been in the last period that the sufficient evidence has been marshaled to make a systematic case across a range of

diseases. Extremely helpful in this task was the development in the recent GBD project of Integrated Exposure–Response functions that link the risks of five diseases across four exposure categories of combustion pollution, in order of exposure levels: ambient air pollution, secondhand tobacco smoke, HAP, and active smoking. The same diseases are caused by each, albeit at risk levels commensurate with their quite different exposure levels (Burnett et al. 2014).

Although basic epidemiological and exposure research continues, given the that this threshold has been passed, there is a need now to examine carefully the paradigms behind efforts to ameliorate the situation as intervention research becomes more to the fore. Here I examine the traditional paradigms that have dominated thinking over the last half century and then propose five new ones to help in the future.

Old Paradigm #1: *Let them eat cake* As the rich use clean fuels and the poor use dirty fuels, let us just wait until everyone is rich, i.e., let development take care of the problem. Unfortunately, however, this has not worked. There are about the same number of people using these fuels today as 25 years ago (2.8 billion) in spite of considerable development occurring since. Sure, more are using clean fuels (gas and electricity), but the absolute burden of exposure has not changed appreciably worldwide, although this varies by region: going up in Sub Saharan Africa, down in East Asia (China), and remaining level in South Asia. Indeed, it is likely that more people are exposed than anytime in human history (Bonjour et al. 2013)

Old Paradigm #2: *Make the available clean* Since the large national stove programs were initiated in India and China in the early 1980s, hundreds if not thousands of programs, small and large, have been initiated worldwide to attempt to promote better stoves using the same fuels now being used locally, mainly different forms of biomass. Although initially focused on efficiency, many of these pro-

grams today are also attempting to lower smoke levels, i.e., make the available fuels clean through better combustion, chimneys, etc. This is not the place to go into details, but unfortunately for a range of reasons, this has turned out to be extremely elusive and it is difficult to point to many successes where health-related exposures have been reduced substantially in a sustained manner for a large population. Much progress has been made, however, and efforts should be continued to upgrade the engineering, business, social marketing, and standard-setting approaches to reach this goal.

Now, based on the new health evidence and the experience noted above, new paradigms are emerging:

New Paradigm #1: *Make the clean available* It is no mystery what works for clean cooking. Gas and electricity are used by 60% of humanity and cook every cuisine without problem. Unlike typical biomass stoves being promoted, they cannot be made dirty at the household even with non-optimal use and do not require any special attention or training. They are also aspirational in the form of fancy looking cooking appliances, an important sales advantage. They are not available to the populations using biomass, however, not only because of cost but also because the public and private infrastructure has not been available or reliable. Any kind of gas, including biogas and natural gas, is clean burning compared to solid fuels, but Liquefied Petroleum Gas (LPG) is usually the first to reach rural areas. Finding ways to push these fuels down, the energy/income ladder to poorer and rural populations needs to be taken on in a serious manner. This is beginning in several countries and engages entirely new actors, including petroleum, gas, and power industries and associated ministries (Smith, 2002; Smith and Sagar, 2014).

New Paradigm #2: *Embrace leap frog technologies* When we do not use our father's landline phone or broadcast TV, why should we use our mother's stove when there are highly advanced, electro/electronic devices for cooking? Depending on task, induction stoves are 50% more efficient and 50% faster as well as safer and longer lived than old-style electric stoves. They are so different, in fact, that they provide for the first time in decades a new entry onto the cookstove landscape. Sales are booming in Asia and prices are dropping, reaching \$10 each, but at present, purchases are among customers using LPG or natural gas as it is often cheaper to cook with induction even compared to subsidized LPG. How far, however, might induction stoves be pushed into rural areas when electricity supply becomes more reliable? The country of Ecuador, for example, is replacing every stove in the country with induction, even if it is the most rural in

South America. In addition, linking induction cooking with locally generated power from renewable sources would be a very exciting prospect (Smith 2014).

New Paradigm #3: *It takes a village* Research shows that in many circumstances, changing one household at a time in a village to clean fuels creates less reduction of exposures than one might expect. This is because of a sort of "herd" effect, i.e., even if you cook on LPG (or do not cook at all), you are affected by all your neighbors who still cook on biomass stoves. Despite varying by geography and meteorology, it is clear that most of humanity lives in fairly close quarters whether in cities or villages, and thus this problem is common. The most effective interventions therefore are likely to occur at the community level. This has two other advantages besides countering the "herd" effect, (1) it is usually more efficient to provide fuels, stoves, service, etc., at community scale, lowering costs and increasing reliability and (2) one can unleash social pressure to help change the social norms—e.g., create a smokeless village designation that would encourage neighbors to work together (put pressure on each other) to avoid smoke production in their village.

New Paradigm #4: *Indoor goes outdoors* A major reason that the field has moved away from the term "indoor air pollution" to HAP is the realization that although the pollution may start in the kitchen, it moves to the household and community environment and thence adds to general ambient air pollution. The degree that this matters depends on the situation, but in India, the estimate is that about one-quarter of primary ambient airborne particulate matter less than 2.5 microns in size (PM_{2.5}) in the country comes from household cookfuels (Chafe et al. 2014). Clearly, therefore, cleaning up household fuels is a necessary step in dealing with the serious outdoor pollution problem in many countries. It is also clear that "indoor" is a bit misleading in that it implies that, for example, a chimney would fix it. All a chimney does is to move the smoke a couple of meters; however, it comes back into the bedroom, stays around the house, goes next door, and goes downwind to affect other villages and even cities. Although a working chimney helps reduce exposures, it is best not to generate the smoke in the first place.

New Paradigm #5: *It is a health problem, stupid* As a health scientist, I would have said I have always treated HAP as a health issue, but recently, I realize that I have too much thought it an energy access problem. The health sector does not have non-governmental organizations (NGOs) developing vaccines in villages to try out in hundreds of efforts around the world: it taps the very best advanced scientific,

technological, and manufacturing techniques to develop effective vaccines which, after proving their worth in highly structured field trials, then are made available through pre-purchase, royalty agreements, and mass manufacture to bring down the cost. Then, it taps NGOs and others in bringing them to vulnerable populations. The health sector tries to treat all the same: it does not promote less-effective antibiotics in rural areas because they are poor, which the energy sector does. Taste of food is often given as a reason for not changing from open fires, but the health sector would ask whether it is worth a million lives a year in India? It does not stop because people like the taste of tobacco or salt or not using condoms but brings in the needed social pressure to change those tastes. Also the health sector has recognized already the importance of various kinds of “herd” effects, for example with sanitation and mosquito protection. First and foremost is effectiveness at scale, not starting first with a business model selling house to house, which may come later. Finally, it is not afraid of “subsidies” but provides the evidence needed to establish that expenditures on the health of the poor are cost-effective social investments.

The link between human fecal matter and disease was firmly established by 1890, but still billions suffer from poor water, hygiene, and sanitation after 125 years. Now that the link between HAP and ill health is established, let us try to bring modern technology, the best health science, smart financing, social marketing, etc., to bear to do much better for household air pollution.

ABOUT THE ARTWORK

The cover art is in the style of a Mughal miniature painting that originated in the seventeenth century. Although the artist is unknown, the paintings that came out of the Mughal dynasty are known for incorporating techniques from Persian, Indian, and other European artists. The amalgamation of these distinctive techniques created the Mughal style that influenced further art in the Indian subcontinent for centuries (http://www.metmuseum.org/toah/hd/mugh_2/hd_mugh_2.htm)

ON THE COVER

Miniature painting in the style of Mughal art (~1600) by unknown artist showing a woman cooking over an open biomass stove as done in hundreds of millions of household today. Ink, opaque watercolor, and gold on paper, 4.3 × 7.2 in.



Kirk R. Smith

Division of Environmental Health Sciences, School of Public Health,

University of California, Berkeley, CA, USA

e-mail: krksmith@berkeley.edu

REFERENCES

- Bonjour S, Adair-Rohani H, Wolf J, Bruce N, Mehta S, Pruss-Ustan A, Lahiff M, Rehfuess E, Mishra V, Smith KR (2013) Solid fuel use for household cooking: Country and regional estimates for 1980–2010. *Environmental Health Perspectives* 121:784–790
- Burnett RT, Pope CA, Ezzati M, Olives C, Lim SS, Mehta S, Shin HH, Singh G, Hubbell B, Brauer M, Anderson HR, Smith KR, Balmes J, Bruce N, Kan F, Laden F, Prüss-Ustün A, Turner MC, Gapstur SM, Diver WR, Cohen A (2014) An Integrated risk function for estimating the Global Burden of Disease attributable to ambient fine particulate matter exposure. *Environmental Health Perspectives* 122:397–403

- Chafe Z, Brauer M, Klimont Z, Van Dingenen R, Mehta S, Rao S, Riahi K, Dentener F, Smith KR (2014) Household cooking with solid fuels contributes to ambient PM_{2.5} air pollution and the burden of disease. *Environmental Health Perspectives* 122:1314–1320
- Lim SS, Vos T, Flaxman AD and many others (2012) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010, *Lancet*, 380: 2224–60.
- Padmavaty S, Pathak SN (1959) 1959, Chronic cor pulmonale in Delhi: A study of 127 cases. *Circulation*. 20:343–352
- Smith KR (2002) In Praise of Petroleum? *Science* 298:1847
- Smith KR (2014) In Praise of Power. *Science* 345:603
- Smith KR, Bruce N, Balakrishnan K, Adair-Rohani H, Balmes J, Chafe Z, Dherani M, Hosgood HD, Mehta S, Pope D, Rehfuess E, and others in the HAP CRA Expert Group (2014) Millions dead: how do we know and what does it mean? Methods used in the Comparative Risk Assessment of Household Air Pollution, *Annual Review of Public Health*, 35: 185–206.
- Smith KR, Sagar A (2014) Making the clean available: Escaping India's chulha trap. *Energy Policy* 75:410–414

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