

Commentary 3: The Environment and Health in LMICs

Taylor Jezuit

Global Health

April 27, 2018

The world around us and the environment in which we live have long been known to play a major role in the health of populations. Air pollution has now become the world's largest

environmental health risk (Mannucci & Franchini, 2017) and indoor air pollution is also of great concern (Bruce, Perez-Padilla, & Albalak, 2000). Much of the burden of disease related to environmental pollution falls on low- and middle-income countries (LMICs) (“Inheriting a sustainable world?”, 2017). Vulnerable populations such as pregnant women, newborns, and children are at a magnified risk for health problems resulting from air pollution (Mannucci & Frannchini, 2017). In 2015, 26% of deaths of children under five could have been prevented through environmental risk interventions (Pruss-Ustun et al., 2016). Because indoor air pollution is a large contributor to outdoor air pollution and has such severe consequences, I chose to focus on improving indoor air pollution in one of the areas where rates of this pollution are the highest, Sub-saharan Africa. The use of improved cookstoves in conjunction with distinct kitchen areas separate from the home will decrease pollutant exposure, thus decreasing under 5 death.

I chose to intervene on indoor air pollution because of the negative health implications this type of pollution has on vulnerable populations and because reducing air pollution has the potential to address several of the United Nation’s Sustainable Development Goals (SDGs) including: SDG 3: Good health and well-being; SDG 7: Affordable and clean energy; SDG 10: Reduce inequality within and among countries; SDG 11: Sustainable cities and communities; and SDG 13: Climate action (United Nations, 2016). It is imperative to keep these goals at the forefront of global public health interventions. In my estimation, the greater the number of potentially improved outcomes, the more worthwhile the intervention.

Pollution results in 9 million deaths per year. This equates to 15% of deaths worldwide of which 90% occur in LMICs (Preker et al., 2016). Childhood mortality makes up a large portion of these deaths. In 2012 it was estimated that 26% of childhood deaths and 25% of total disease burden in children under five could have been prevented through reduction of environmental risk

factors (“Don’t pollute my future!”, 2017). Compared to other forms of environmental pollution (water, soil, and occupational), air pollution causes the greatest number of environmental pollution-related deaths (Landrigan et al., 2017). Globally, more than 4 million deaths occur yearly due to indoor air pollution resulting from cooking fuel in LMICs and children under-five are the most vulnerable (Owill et al., 2017). Household (or indoor) air pollution resulting from solid fuel use has been estimated to be one of the top five major risk factors for global burden of disease, being globally responsible for 4.1% of all Disability-Adjusted Life Years (DALYs) (Mannucci & Franchini, 2017). Among children, lower respiratory infections are one of the largest causes of mortality. In 2015, 15.5% of child under five deaths were caused by lower respiratory infections. Critical risk factors for these infections include indoor air pollution, ambient air pollution, and second-hand tobacco smoke (“Don’t pollute my future!”, 2017).

Indoor air pollution is of concern in developing countries because approximately 50% of people, almost all in developing countries, rely on coal and biomass for domestic energy (Bruce, Perez-Padilla, & Albalak, 2000). Sub-Saharan Africa in particular is the focus of this paper because 18 of the 20 countries most affected by indoor air pollution were in Sub-Saharan Africa (International Energy Agency, 2016). 4 out of 5 of Sub-Saharan Africa’s population utilize biomass fuels (Owill et al., 2017). Biomass is any material derived from plants or animals which is deliberately burnt by humans. Wood, dung and crop residues are common forms of biomass fuel (Bruce, Perez-Padilla, & Albalak, 2000). These biomass fuels are typically burned in open fireplaces with poor ventilation in which combustion is incomplete and results in substantial emissions into the home.

Women and children living in LMICs have the greatest exposure to indoor air pollution that results from these conditions (Mannucci & Franchini, 2017). This is because of women’s

customary involvement in cooking, child care, and other responsibilities centered within the home. Children are typically around the mother and infants are often carried on their mothers' backs while these activities are carried out. Thus, these children are also spending hours being exposed to indoor air pollutants (Bruce, Perez-Padilla, & Albalak, 2000). This exposure to air pollutants can be detrimental because children are especially vulnerable due to their developing immune systems, smaller bodies and airways. Proportionate to their size, children breathe more air than adults ("Don't pollute my future!", 2017). Children also have higher rates of absorption and retention of toxic substances from air pollution (Owil et al. 2017), further increasing their risk from air pollutants.

The most important air pollutants when considering health consequences are particulate matter (PM), carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde, and polycyclic organic matter (including carcinogens such as benzopyrene) (Bruce, Perez-Padilla, & Albalak, 2000). Primary pollutants are emitted directly into the air by the combustion of fossil fuels. Examples of primary pollutant include soot particles, nitrous oxides, and sulphur oxides. Secondary pollutants are formed when primary pollutants interact with the atmosphere. Examples of secondary pollutants include ozone and particulate matter (Schwarze et al., 2006). Particles with a diameter under 10 microns (PM 10), particularly those with a diameter less than 2.5 microns (PM 2.5) are of greatest interest in environmental health because of the damaging affects they have on health. PM 2.5 can penetrate deeply into lung tissue, causing a variety of serious respiratory issues (Bruce, Perez-Padilla, & Albalak, 2000). PM 2.5 is derived from combustion processes such as wood burning and coal burning for power and heat generation. These particles present increased health risks because they are capable of traveling more than 100 kilometers. (Mannucci & Franchini, 2017).

Concentration of indoor pollution in LMICs typically exceed guideline levels by a large margin. For example, mean 24-hour levels of PM 10 range from 300-3000 micrograms per cubic meter and during times of cooking can reach 30,000 micrograms per cubic meter. 24-hour levels of carbon monoxide (CO) in homes that burn biomass fuels in LMICs range from 2-50 parts per million (ppm), increasing during cooking to 10-500 ppm (Bruce, Perez-Padilla, & Albalak, 2000). To gain more specific data on pollutant concentrations in SSA specifically, we look at a study conducted in 45 Kenyan homes. In homes that used traditional cookstoves to burn biomass fuel, 48-hour PM 2.5 concentration was 586 micrograms per cubic meter and CO concentration was 6.5 ppm (Pilishvili et al., 2016). The WHO air quality guideline level of 24-hour PM 2.5 concentrations is 35 micrograms per cubic meter and the guideline for 24-hour CO concentration is 6.11 ppm (WHO, 2017). Thus, the indoor pollution levels in SSA are of great concern to public health. People in LMICs countries are typically exposed to extremely high levels of pollution for 3-7 hours daily and this pattern occurs over many years creating a substantial increase in risk for disease (Bruce, Perez-Padilla, & Albalak, 2000).

Indoor air pollution is associated with an increased risk of a variety of poor health conditions including lower and upper respiratory infections, such as pharyngitis, laryngitis, sinusitis, and otitis media (“Don’t pollute my future!”, 2017). Other health complications associated with indoor air pollution are chronic bronchitis, chronic obstructive pulmonary disease, asthma, pulmonary tuberculosis, and various types of cancer. Acute lower respiratory infections are the single largest cause of mortality in children under 5, accounting for approximately 2 million deaths annually (Bruce, Perez-Padilla, & Albalak, 2000). A study conducted by Owil et al. used cross sectional data from 23 countries in Sub-Saharan Africa collected through the Demographic Health Survey and found that exposure to charcoal

resulted in a hazard ratio of death for children under five of 1.20 compared to exposure to clean fuels. Additionally this study found that exposure to biomass fuels resulted in a hazard ratio of 1.21. Kitchen location was another variable measured in this study and it was found that within the home kitchen areas further increased child exposure to the burning of biomass fuels and charcoal (Owil et al., 2017). This has important implications for efforts to reduce exposure to indoor air pollution. Moving the kitchen space to a location distinct from the main house in SSA will help reduce exposure to these pollutants. Adding to the disease burden of indoor air pollution, maternal exposures can have their own set of health implications. Studies have shown maternal exposure to burning of biomass fuels in LMICs is associated with anywhere from a 63 gram decrease in birth weight to a 175 gram decrease in birthweight (Bruce, Perez-Padilla, & Albalak, 2000).

In order to reduce the health consequences of indoor air pollution, sources of the pollution need to be eliminated and exposure to these sources need to be reduced. Therefore a two-fold approach addressing these two conditions will be most effective at reducing under five mortality in SSA. Because energy sources become more costly the cleaner, more convenient, and efficient they are, a major barrier for use of these energy sources in LMICs such as SSA is cost. Given that 90% of those in LMICs using biomass fuel live in rural areas, the economic challenges to cleaner energy are further elevated (Bruce, Perez-Padilla, & Albalak, 2000). Replacing traditional stoves used by homes in SSA and moving the location of the kitchen will reduce the emission of pollutants and also the exposure to these pollutants.

Studies have shown that using improved biomass cookstoves (ICS) can significantly reduce kitchen levels and personal levels of PM 2.5 and CO compared to traditional biomass cookstoves (Pilishvili et al., 2016; Yip et al., 2016). Six ICS's have been evaluated and all have

shown a reduction in pollutant levels in both studies. For this paper, I will focus the Phillips stove which was found in a qualitative assessment to be preferred among mothers due to its ease of use and cooking speed (Yip et al., 2016). The Phillips stove is an electric fan-assisted gasifier with a ceramic combustion chamber that centrally manufactured, can be easily transported, and requires no assembly (Pilishvili et al., 2016). Rechargeable batteries and a solar panel are used to run the Phillip stove and are to be included in the supplies provided to homes in SSA through this proposed intervention. This ICS was also found to have the largest reductions in kitchen PM_{2.5} and CO levels, by 42.3% and 34.5% reductions from baseline respectively (Pilishvili et al., 2016). Personal CO level reductions were also found in women and children using the Phillips stove compared to a traditional cookstove. There was a significant 59.2% reduction in personal CO levels (Yip et al., 2016). Taken in combination, the qualitative and quantitate results provide strong evidence for the utilization of the Phillips stove in SSA to reduce under five mortality caused by lower respiratory infections. Research has also suggested there are benefits to having a kitchen area separate from the main living space and thus it is encouraged that the Phillips stove be placed in a distinct kitchen area to further avoid pollutant exposure (“Don’t Pollute my Future!”, 2017).

Also worth noting, are the reductions in health care expenditures that can accompany the use of improved cookstoves in more ideal locations in this region. The relative share of spending on polluted related illness is substantial in LMICs and because these environmental factors are preventable, these costs can be reduced through this intervention. Healthcare expenditures in LMICs that result from air pollution were estimated to be 8 million United States dollars in 2013 (Preker et al., 2016). When evaluating the potential for this proposed intervention, the health benefits, as well as the cost benefits should be considered.

Of course a better long-term solution to under 5 mortality caused by indoor air pollution is the utilization of cleaner fuels such as petroleum gas. However, the economic feasibility for that to occur in SSA is low and action must be taken now to reduce preventable deaths. Introducing the Phillips stove to homes in SSA and instructing that these stoves be placed in areas separate from the main home, will result in decreased under five mortality. This intervention also has potential to help the world reach several of the aforementioned Sustainable Development Goals.

References

- Bruce, N., Perez-Padilla R., & Albalak, R. (2000). Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization* 78(9): 1078-1092.
- Don't pollute my future! The impact of the environment on children's health. (2017) Geneva: World Health Organization.
- Inheriting a sustainable world? Atlas on children's health and the environment. (2017) Geneva: World Health Organization.
- International Energy Agency: Energy and Air Pollution – World Energy Outlook Special Report (2016). Paris: International Energy Agency. Retrieved from: <http://www.iea.org/publications/freepublications/publication/>
- Landrigan, P.J., Fuller, R., Acosta, N.J.R., Adeyi, O., Arnold, R., Basu, N., Baldé, A.B., Bertollini, R., Bose-O'Reilly, S., & Boufford, J.I. (2017). The Lancet Commission on pollution and health. *Lancet*.
- Mannucci, P.M., & Franchini, M. (2017). Health effects of ambient air pollution in developing countries. *International Journal of Environmental Research and Public Health* 14(1048).
- Owili, P.O., Muga, M.A., Pan, W & Kuo, H. (2017) Cooking fuel and risk of under-five

- mortality in 23 Sub-Saharan African countries: a population-based study, *International Journal of Environmental Health Research*, 27:3, 191-204.
- Pilishvili, T., Loo, J.D., Schrag, S., Stanistreet, D., Christensen, B., Yip, F., Nyegol, R., Quick, R., Sage, M., & Bruce, N. (2016). Effectiveness of six improved cookstoves in reducing household air pollution and their acceptability in rural western Kenya. *PLoS ONE* 11(11).
- Preker, A.S., Adeyi, O.O., Lapetra, M.G., Simon, D., & Keuffel, E. (2016). *Annals of Global Health* 82(5): 711-721.
- Prüss-Üstün A, & Corvalán C (2006). Preventing Disease through Healthy Environments: Towards an Estimate of the Environmental Burden of Disease. Geneva, Switzerland: World Health Organization.
- Schwarze, P.E., Ovreik, J., Lag, M., Refsnes, M., Nafstad, P., Hetland, R.B., & Dybing, E. Particulate matter properties and health effects. Consistency of epidemiological and toxicological studies (2006). *Human Exp. Toxicology*. 25: 559–579.
- United Nations: Sustainable Development Goals (2016). New York: United Nations. Retrieved from: <http://www.un.org/sustainabledevelopment/>
- WHO. Ambient (Outdoor) Air Quality and Health. Retrieved from: <http://www.who.int/mediacentre/factsheets/fs313/en/>
- Yip, F., Christensen, B., Sircar, K., Naeher, L., Bruce, N., Pennise, D., Lozier, M., Pilishvili., Farrar, J.L., Stanistreet, D., Nyagol, R., Muoki, J., de Beer, L., Sage, & M., Kapil, V. (2016). Assessment of traditional and improved stove use on household air pollution and personal exposures in rural western Kenya. *Environment International* 99: 185-191.