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gOVERVIEW

EDITORS' PAGE

Household Air Pollution: An Emerging Risk Factor for CVD

Arun Chockalingam *, H. Eser Tolunay †, Dorairaj Prabhakaran ‡, Jagat Narula §
Bethesda, MD, USA; New Delhi, India; and New York, NY, USA

The United Nation's High-Level Meeting on Prevention and Control of Non-Communicable Diseases in New York on September 20, 2011, released a declaration [1] on prevention and control of noncommunicable diseases (NCD). The United Nations identified 4 major chronic diseases—cardiovascular diseases including stroke, cancer, chronic respiratory disease, and diabetes mellitus as the major contributors of worldwide disease burden. While researchers studying these diseases, in depth, have identified the key role played by diet, physical activity, tobacco smoking, and to a certain extent alcohol in determining NCD risk, scant attention has been paid to understanding the adverse effects of household air pollution (HAP) on health worldwide. This is particularly true of low- and low-middle-income countries (LMIC) where the dependence on solid fuel, such as wood, charcoal, and a variety of dried animal dung results in a high degree of air pollution. By contrast, much of the high-income countries or much of the developed world enjoy the use of liquid and gaseous fuel with relatively no air pollution around the kitchen and the interior of the house. Further complications of HAP are due to the type of cook stoves people use in many LMIC and the design of the kitchen with little ventilation or no chimneys to get the fumes out.

If we are serious about addressing the growing burden of NCD and achieving the Millennium Development Goals (MDG), we cannot ignore the ill effects of HAP in LMIC, which constitute nearly two-thirds of the global population [2]. Therefore, this high burden of HAP among LMIC calls for the intense advocacy efforts, not only to change practices, but policy initiatives in promoting clean cooking fuels and research in identifying low-cost solutions. Given this scenario, we are dedicating a full issue on HAP with contributions from eminent researchers in this field.

As seen in Dr. William Martin's preface [3], nearly 3 billion people from LMIC depend on the solid fuels. The adverse health effects of solid fuel–generated HAP have not been well understood. Although Dr. Padmavati [4] from New Delhi, India, documented cor pulmonale (pulmonary heart disease) as early as 1959, the cardiovascular community either ignored or did not understand the serious implications of HAP to cardiovascular diseases (CVD). Some 5 decades later, we are now coming around to re-evaluate the effect of HAP and its implications on CVD.

The U.S. Department of Health and Human Services including the National Institutes of Health, the Centers for Disease Control and Prevention, and the Secretary's Office of Global Health Affairs, U.S. Department of State, U.S. Environmental Protection Agency, and U.S. Agency for International Development held a 2-day international workshop on Health Burden of Indoor Air Pollution on Women and Children in Developing Countries in Arlington, Virginia, on May 9 to 11, 2011, and brought together researchers from different disciplines, for the first time, to get a real perspective on HAP. Interaction between NCD and environmental scientists, cook stove design engineers, and policymakers provided deeper insights to understand the complex HAP and disease spectrum. In this special issue of *Global Heart*, many of the experts in cardiovascular and pulmonary science have contributed either state-of-the-art, or original work in LMIC

From the *Office of Global Health, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD, USA; †Division of Cardiovascular Sciences, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD, USA; ‡Centre for Chronic Disease Control, Public Health Foundation of India, New Delhi, India; §Department of Global Health, Mount Sinai School of Medicine, New York, NY, USA. Correspondence: A. Chockalingam (chockalingama@nhlbi.nih.gov).

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settings. The HAP–cardiometabolic and cardiopulmonary diseases field is very young and a deeper understanding is warranted.

Rajagopalan and Brook [5] provide an overview and magnitude of the burden of HAP on CVD. Particulate matter, a major component of HAP, is a recognized modifiable risk factor for cardiovascular morbidity and mortality [6]. Evidence for this conclusion came from outdoor air pollution studies. Rajagopalan and Brook point out that the particulate matter levels experienced indoors in LMIC are between those found in outdoor air pollution and active smoking and are typically several magnitudes higher than the outdoor levels are [7,8]. They call for action in 5 broad categories: 1) exposure assessment; 2) epidemiologic studies; 3) technological and educational interventions; 4) economics of intervention and healthcare costs; and 5) mechanistic studies linking cardiovascular health with exposure to HAP.

McCracken and colleagues [9] review the studies on HAP and CVD, as well as plausible mechanisms through which HAP might contribute to cardiovascular morbidity and mortality. Although the number of studies on HAP and CVD, to date, are limited, findings support the hypothesis that HAP is a likely risk factor for CVD. They also provide evidence from a randomized exposure study (RESPIRE [Randomized Exposure Study of Pollution Indoors and Respiratory Effects]) that improving indoor air quality by introducing more efficient cook stoves and better ventilation will reduce the burden of CVD in LMIC.

The principal sufferers of the HAP are women and children who spend significant amounts of time in the kitchen inhaling smoke and fumes. Thus, HAP is a major contributing factor for maternal and child health. Rabadan-Diehl et al. [10] review the potential in utero effects of HAP on CVD in children in later life. Drawing from research on secondhand smoke, ambient particulate air pollution, and other environmental pollutants found in HAP, and from both animal and epidemiologic studies, they cite evidence for increased risk of CVD for children in later life. Their review supports the notion that exposure to HAP in early life may be an important determinant of adult CVD risk and a contributor to the growing burden of cardiovascular disease in LMIC.

In a 10-year retrospective cohort analysis of a low-income rural adult Bangladesh population, Alam and colleagues [11] compared the cause-specific mortality including cardiopulmonary deaths through verbal autopsy as part of a permanent surveillance. They found, in total, 946 cardiopulmonary deaths occurred with 884 in the solid fuel–using and 62 in the gas-supplied households (n = 7,565 and n = 508, respectively) over the 10-year period. Cardiopulmonary death rate was 6.2 per 1,000 person years (PYs) in people living in households using solid fuel and 5.3 per 1,000 PYs in households using gas. Mortality due to respiratory disease was 1.2 and 0.5 per 1,000 PYs in the solid fuel–using and gas-supplied groups, respectively. They concluded that household solid fuel use is associated with increased respiratory mortality and showed a trend for increased risk of cardiovascular mortality. Reduction of exposure to pollution due to indoor solid fuel use is likely to improve survival in Bangladeshi and similar populations.

Bloomfield and colleagues [12] draw our attention to pulmonary hypertension (PH) and right heart failure (RHF), conditions that are disproportionately high in LMIC. There are many causes of PH and RHF in these countries, including human immunodeficiency virus, schistosomiasis, tuberculosis, chronic obstructive pulmonary disease (COPD), interstitial lung disease, hemoglobinopathies, chronic thromboembolic pulmonary hypertension, rheumatic heart disease, and high altitude. They observe the high prevalence of PH and RHF at locations where HAP levels are high and posit that when individuals with 1 of these 8 common comorbidities are exposed to HAP, they may be predisposed to develop PH and RHF. In addition, there may be a direct link between exposure to HAP and RHF. These relationships deserve further investigation.

The respiratory substudy group at the May 2011 workshop reviewed extensively the literature on HAP and its relationship with COPD or asthma among adults and children. The review and ensuing discussions at the workshop, along with specific recommendations are reported by Diette and colleagues in this issue [13]. This paper analyzes the association of COPD or asthma and HAP in the context of sex, cook stove type (e.g., open fire vs. liquid propane gas) and respiratory symptoms such as wheeze and cough. The investigators' review shows that among the studies that used objective measures, such as spirometry as a health outcome, the data supporting an association between biomass smoke exposure and COPD in adult women are fairly robust, whereas the findings for asthma are less robust. The respiratory substudy group identified a series of scientific gaps and opportunities for research that need to be addressed to better

understand the respiratory effects of exposure to indoor burning of the different forms of biomass fuels.

Baumgartner and colleagues [14] provide an overview to reduce cardiovascular diseases through improvements in household energy and suggest areas for policy-relevant research. The investigators provide a brief summary of what is known about a range of housing, energy, and behavioral interventions to reduce HAP exposures. They conclude that the cook stove is the main source of combustion pollution in many populations and space heating as an important source of pollution in high-elevation or temperate areas. Their review of fuels that have been promoted as ways to reduce HAP exposures reveals that the 4 major categories of fuels replacing traditional solid fuels (wood, crop residues, charcoal, or animal dung) are coal, wood-charcoal, kerosene, and biogas, though each has serious drawbacks. They recognize that a handful of other household energy approaches are being pursued, though these have yet to achieve large market penetration. These include liquid biofuels, processed biomass, solar and electric devices, improvements in housing stock and insulation, and chimney and advanced combustion biomass stoves. Finally, they evaluate implications for household energy interventions and policies as well as future research needs on HAP interventions and CVD from a policy perspective.

Lauer et al. [15] provide examples of successful approaches that resulted in improvements in health and recommend prospective planning and developing a systematic approach to involve diverse stakeholder groups in the development and implementation of research priorities, result-based accountability, and team science to address this serious health burden.

Much work needs to be done to save the nearly one-half of the world population who are exposed to HAP. The papers in this issue set the agenda for future research in this field, more specifically on HAP, cardiovascular diseases, chronic respiratory diseases, and policy-relevant research to reduce HAP in vulnerable populations. If we are to mitigate the ill effects of HAP, we need a strong multidisciplinary approach that involves all stakeholders.

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