EAST-WEST CENTER

Indoor Air Pollution: The Quiet Killer

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SUMMARY Air pollution in big cities gets headlines, but in many rural areas of developing countries indoor air pollution is an even more serious health problem. Long-term exposure to smoke from cooking indoors with wood, animal dung, and other biomass fuels contributes to respiratory illness, lung cancer, and blindness. As a cause of ill health in the world, indoor air pollution ranks behind only malnutrition, AIDS, tobacco, and poor water/sanitation. The results of a national household survey in India linking cooking smoke to tuberculosis and blindness in adults and acute respiratory infections in children add to a growing body of evidence from other studies that reducing exposures to toxic emissions from cookstoves can substantially improve health and save lives. Governments can do more to promote clean fuel use, educate people to the risks of exposure to cook smoke, and provide and promote more efficient and better-ventilated cookstoves. Curbing indoor air pollution is not only a key to better health but also an important investment for achieving development goals and improving living standards.

Around the world, urban air pollution attracts widespread public attention and produces calls for action. Air pollution is all too visible to city residents, and it poses risks to the health of all who breathe polluted air. Yet in rural areas of developing countries, indoor air pollution can be much worse than atmospheric pollution levels in big cities.

Indoor air pollution is a major public health problem in developing countries, where it accounts for much ill health and well over a million deaths annually. Estimates are that several hundred thousand women and children in India alone die prematurely because of indoor air pollution.[i] Data to be released shortly by the World Health Organization (WHO) indicate that, worldwide, indoor air pollution (mostly in developing countries) ranks fifth—behind malnutrition, AIDS, tobacco, and poor water/sanitation—on the percentage of ill health accounted for by various risk factors.[ii] Despite its large effect, it is a quiet killer, hidden from public view, affecting mostly the poor and, among them, women and young children especially.

Indoor air pollution affects mostly the poor and, among them, mostly women and children

Why is the problem of indoor air pollution so widespread? Nearly half of the world's households use unprocessed biomass fuels—wood, animal dung, crop residues, and grasses—for cooking and heating. In the developing countries of South Asia and sub-Saharan Africa, as many as 80 percent of all homes cook with biomass fuels. The proportions relying on biomass fuels are even higher in the rural areas of these countries.

Biomass fuels are an inefficient source of energy. Because combustion is incomplete, burning them in open fireplaces or in simple indoor cookstoves releases large amounts of health-damaging air pollutants. The problem is aggravated, as is often the case in poor rural households, when cooking areas are inadequately ventilated and the dwelling lacks a separate kitchen. Even when biomass cookstoves are vented to the outdoors, they can produce enough noxious emissions to raise pollution levels in the surrounding neighborhood to unhealthy levels.

In homes with poorly ventilated cooking areas, residents—particularly women and the young children under their care—are regularly exposed to noxious pollutants such as respirable particulate matter (i.e., fine particles that can reach deep into the lungs), carbon monoxide, nitrogen oxides, formaldehyde, and dozens of toxic polyaromatic hydrocarbons (such as benzo[a]pyrene). Moreover, fires from biomass fuels require more or less continual feeding, resulting in extended exposure to their smoke. Many people are exposed for three to seven hours daily, and even longer in winter months when houses must also be heated. Because biomass cookstoves are usually used for several hours each day at times when people are present indoors, indoor exposures to airborne pollutants tend to be much greater than outdoor exposures. In such settings, daily average and peak exposures to air pollutants often far exceed safe levels recommended by the World Health Organization. Typical levels of carbon monoxide and respirable particulate matter in developing-country homes that use biomass fuels usually exceed U.S. Environmental Protection Agency guidelines by several times.[iii]

There is a growing body of evidence that long-term exposure to high levels of smoke from burning biomass fuels is linked to a number of specific diseases that are widespread in many developing countries. Exposure to biomass cooking smoke has been linked to a host of respiratory diseases, including acute respiratory infections (ARI), chronic bronchitis, asthma, and tuberculosis. It has also been linked to lung cancer, adverse pregnancy outcomes, cataract, and blindness.

How Does Cooking Smoke Cause Ill Health?

The mechanisms by which cooking smoke causes ill health are only partially understood. Studies have shown that exposure to biomass smoke is associated with compromised pulmonary immune defense mechanisms in both animals and humans. Of the specific pollutants in biomass smoke, exposure to respirable particulate matter has been shown to induce a systemic inflammatory response involving stimulation of the bone marrow, which can contribute to cardiorespiratory morbidity. Other evidence indicates that exposure to polycyclic aromatic hydrocarbons—especially benzo[a]pyrene, which is found in large quantities in biomass smoke—can cause immune

suppression and can increase the risk of infection and disease. Benzo[a]pyrene, a known carcinogen, also can increase the risk of lung and other types of cancers.

Acute exposures to oxides of nitrogen, commonly found in biomass smoke, have been associated with increased bronchial reactivity and susceptibility to bacterial and viral infections. Carbon monoxide in biomass smoke combines with hemoglobin to form carboxyhemoglobin, which reduces the oxygen-carrying capacity of the blood and can contribute to anemia and adverse pregnancy outcomes, including miscarriage, stillbirth, low birth weight, and early infant mortality. Extended exposure to biomass smoke has also been shown to cause oxidative damage to the eye lens and can cause cataract.

People living in households that cook with wood and dung are 2.6 times more likely to suffer from active TB

The quantity and quality of scientific literature on the health effects of cooking smoke vary considerably by type of disease. Many studies have examined the effects of cooking smoke on ARI in children.[iv] Several of them show that young children living in homes that burn biomass fuels have two to three times the risk of developing serious respiratory infections than children who are not exposed. A number of studies have shown that women in developing countries who cook with biomass fuels have two to four times the risk of chronic obstructive pulmonary disease (e.g., chronic bronchitis) than women who cook with cleaner fuels. Several studies, but not all, have shown a positive association between cooking smoke and asthma.[v] On the other hand, only a handful of studies have examined the effects of cooking smoke on tuberculosis, lung cancer, pregnancy outcomes, eye ailments, heart disease, and other health outcomes.

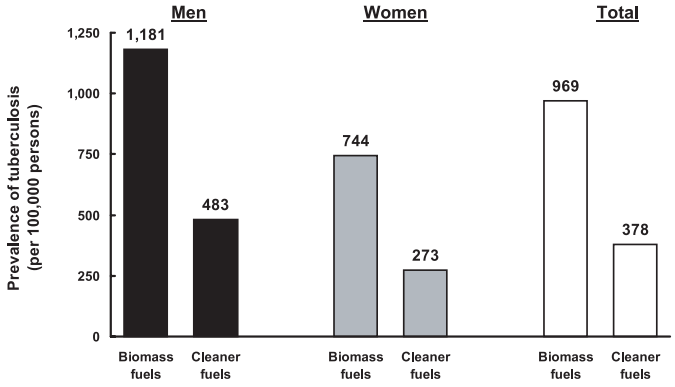

Fig. 1. Prevalence of active tuberculosis by type of cooking fuel among persons age 20 years and older, India

This issues paper reports on findings from three studies that link exposure to cooking smoke to tuberculosis, acute respiratory infections, and blindness, based on data from a national household survey in India. All results reported here were controlled for demographic and socioeconomic factors (see box).[vi–viii]

Fueling the Spread of Tuberculosis

Tuberculosis, which kills about 2 million people each year worldwide, is resurgent. "Tuberculosis, which many of us believed would disappear in our lifetime, has staged a frightening comeback," says Gro Harlem Brundtland, Director-General of the World Health Organization.

TB is an airborne contagious disease that is transmitted by coughing, sneezing, or even talking. Once a person becomes infected, any condition that weakens the immune system can trigger the development of active TB. Typically about 5–10 percent of infected persons eventually develop active TB. In many countries TB is on the rise as HIV/AIDS spreads, as drug-resistant strains of the disease become more common, and as health systems fail to respond adequately.

Exposure to cooking smoke can increase the risk of TB by reducing resistance to initial infection or by promoting the development of active TB in already-infected persons. As indicated earlier, extended exposure to the pollutants contained in biomass smoke can weaken the immune system, impair the lungs, and make them more susceptible to infection and disease. Cooking smoke also tends to increase coughing, which contributes to the spread of TB infection.

Tuberculosis is common in India, where about half of the adult population are infected with TB bacteria, millions have active disease, and about half a million die from it every year. Data from India's National Family Health Survey show that people living in households that cook with wood and dung are 2.6 times more likely to suffer from active TB than adults in households using cleaner fuels (Figure 1).[vi]

As might be expected—because women do most of the cooking and are more exposed to indoor air

India's National Family Health Survey

India's 1992–93 National Family Health Survey collected socioeconomic, demographic, and health information from a nationally representative survey of about 89,000 households. East-West Center researchers played a major role in the design, implementation, and analysis of the survey, which asked a number of questions about the current health status of household members—including questions about tuberculosis, acute respiratory infections, and partial and complete blindness.

In the case of tuberculosis, the household head or other knowledgeable adult in the household reported whether each household member suffered from active tuberculosis. In the case of blindness, the household respondent reported whether each household member suffered from partial or complete blindness. In the case of ARI, the mothers of young children were asked whether the child had been ill with a cough during the two weeks before the survey and, if so, whether the child breathed faster than usual with short, rapid breaths. The survey did not test clinically for active tuberculosis, blindness, or ARI.

The survey also asked about the primary cooking fuel used in the household. In the analysis, fuel type serves as an indirect measure of exposure to cooking smoke. (Indoor air pollution measurements in developing countries have shown fuel type to be the best single indirect indicator of household pollution levels.) The survey asked about the following fuel types: wood, dung cakes, coal/coke/lignite, charcoal, kerosene, electricity, liquefied petroleum gas (LPG), biogas, and a residual category of other fuels.

Information on fuel types was used to group households into categories representing extent of exposure to cooking smoke—high pollution fuels (wood, dung cakes), medium pollution fuels (coal/coke/lignite, charcoal, kerosene), and low pollution fuels (LPG, biogas, electricity). Because the differences in disease prevalence between the medium- and low-pollution fuel categories were generally small, only two categories (biomass fuels, cleaner fuels) were ultimately used in the analysis.

The analysis of the effect of fuel type on TB, ARI, and blindness controlled for several demographic and socioeconomic factors that affect both exposure to cooking smoke and disease prevalence. These factors are age, sex, urban/rural residence, education, religion, caste/tribe, availability of a separate kitchen, housing type (based on the quality of construction of roof, walls, and floor), indoor crowding, and geographic region. The analysis did not control for exposure to tobacco smoke because the survey did not ask about smoking. For the same reason, the analysis did not take into account the household's history of fuel use, fuel mix, or utilization of medical services. To some extent, however, the socioeconomic variables control indirectly for utilization of medical services.

pollution than are men—women are more affected than men. Figure 1 shows that, with other factors controlled, active TB is 2.7 times more common among women and 2.4 times more common among men in households that cook with wood and dung than in households that do not. Among both men and women, the effect of exposure to cooking smoke is also greater in rural areas than in urban areas, perhaps mainly because medical services to treat TB are less widely available in rural than in urban areas.

About half of active TB among Indian adults is attributable to exposure to biomass cooking smoke

The analysis estimated that about half of active TB among Indian adults is attributable to exposure to biomass cooking smoke. This statistic reflects not only the large effect of biomass smoke on the risk of TB but also the widespread use of biomass fuels for cooking. In rural areas nearly three-fifths of active TB is attributable to biomass cooking smoke, and in urban areas nearly one-quarter, reflecting both a bigger effect of biomass smoke and wider use of biomass fuels in rural areas than in urban areas.

A study in Mexico has confirmed the strong link between biomass smoke and TB found in India (see box). The similar findings from the India and Mexico studies, which were based on quite different research designs, are persuasive and have important public health implications worldwide.

Exacerbating Acute Respiratory Infections in Children

ARI is a disease category that includes severe respiratory infections from a range of viruses and bacteria with similar symptoms and risk factors. ARI is a leading cause of childhood illness and death worldwide, accounting for an estimated 6.5 percent of the global burden of disease. More than three million

children under age five die from ARI every year, mostly in developing countries. In India, as in many other developing countries, pneumonia and other acute respiratory infections cause much illness, suffering, and death among young children.

About 20% of acute respiratory infections among children under age three are attributable to cooking smoke

Analysis of the India survey shows that, with other variables controlled, children under age three living in households that cook using biomass fuels are 32 percent more likely to have suffered from ARI than children in households that cook using cleaner fuels (Figure 2).[vii]

The prevalence of ARI is considerably lower among girls than among boys, and the effect of cooking smoke on ARI is smaller for girls than for boys. The prevalence of ARI is 40 percent higher for boys and 22 percent higher for girls in households using biomass fuels than in households using cleaner fuels. A lower prevalence of ARI among girls could occur if there is more underreporting of ARI for girls than for boys. Similarly, a lower effect of cooking smoke on ARI for girls, relative to boys, could occur if underreporting of ARI for girls is greater in households that use biomass fuels than in households that use cleaner fuels. The sex differentials could also occur if, as is common in India, mothers are more likely to carry young boys or keep them in the kitchen area while cooking than young girls, thereby inadvertently exposing boys to higher levels of air pollution. In this case, ironically, discrimination against girls may work to their advantage.

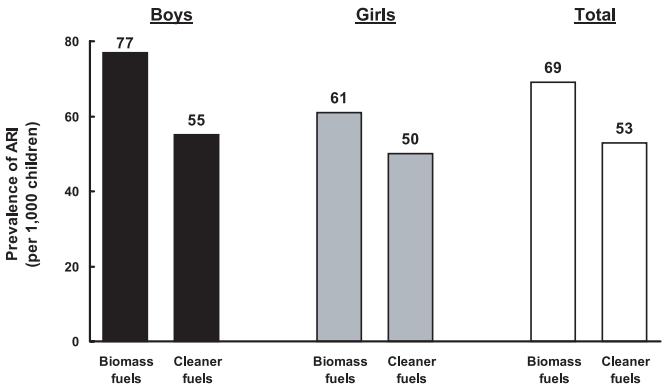

Fig. 2. Prevalence of acute respiratory infections by type of cooking fuel among children under 3 years of age, India

Mexican Study Confirms Link Between Cooking Smoke and TB[ix]

In Mexico, wood is the primary cooking fuel used in about half of all households and nearly 70 percent of rural households. In order to test the India finding of a large effect of cooking smoke on TB, researchers at the National Institute of Respiratory Diseases in Mexico City conducted a hospital-based case-control study in 1998–99.

The study compared nearly 300 patients with clinically confirmed cases of TB, by extent of exposure to cooking smoke from traditional wood stoves. The study compared the patients with confirmed TB with an otherwise similar control group of over 500 patients who had ear, nose, or throat ailments but did not have TB.

After controlling for the socioeconomic status of participating patients, the study estimated an effect of cooking smoke on TB similar in magnitude to that reported in the India study. With socioeconomic status controlled, patients from households with wood-burning stoves were found to be 2.4 times as likely to have active TB as patients from non-wood-burning households—compared with 2.6 times in the India study. In the Mexico study, the link between wood smoke exposure and TB was additionally found to be independent of exposure to cigarette smoke.

The analysis estimated that about 20 percent of acute respiratory infections among children under age three are attributable to cooking smoke. As with TB, this statistic reflects not only the effect of biomass smoke on ARI but also the widespread use of biomass fuels for cooking in India.

Contributing to Partial and Complete Blindness

Blindness is another important public health problem in many developing countries. In India, an estimated 30 million people suffer from partial or complete blindness—tragically high numbers for a usually preventable condition. According to India's National Family Health Survey, 8 percent of women age 30 and older suffer from partial or complete blindness, the prevalence of which increases rapidly with age. Most blindness is partial—that is, seriously impaired

vision due to blindness in one eye, partial cataract, night blindness, or any other eye ailment.

Long-term exposure to cooking smoke probably contributes to impaired vision and blindness mainly through oxidative damage to the eye lens and severe eye irritation, leading to cataract and other disorders. In India, cataract accounts for more than 80 percent of complete blindness. Another direct cause of blindness, conjunctivitis, may also be aggravated by long-term exposure to cooking smoke. Trachoma, which also can cause blindness, can be contracted when irritation from exposure to cooking smoke causes people to rub their eyes frequently.

In China, 200 million improved cookstoves have been introduced, proof that concerted action can achieve remarkable results

Anecdotal association between eye problems and cooking smoke is common, but epidemiological studies of this association are few. There exist a few laboratory studies that have linked cataract to both wood smoke and tobacco smoke. A case-control study of 1,990 patients at a New Delhi ophthalmic clinic showed that, after controlling for other variables, use of wood and dung for cooking was significantly associated with cataract.[x]

The analysis of the India survey estimated that women in households using biomass fuels are 27 percent more likely to suffer from partial blindness and 35 percent more likely to suffer from complete blindness than women in households using cleaner fuels (Figure 3). The study estimated that 17 percent of partial blindness and 20 percent of complete blindness among Indian women aged 30 and older are attributable to cooking smoke.[viii]

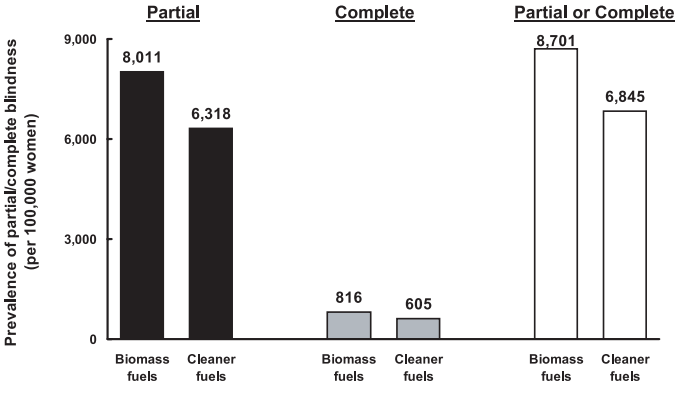

Fig. 3. Prevalence of partial and complete blindness by type of cooking fuel among women age 30 years and older, India

What Can Be Done?

Recognizing the adverse health consequences of indoor air pollution is easier than addressing the problem effectively. Widespread adoption of cleaner fuels probably would do most to reduce indoor air pollution, but poor households that currently rely on biomass fuels are unlikely to be able to afford cleaner fuels any time soon. And because few poor people can afford to use cleaner fuels, markets have yet to develop to supply them, so many rural communities lack access to improved cookstoves and cleaner sources of energy.

In the long run, rising levels of development will reduce indoor air pollution from cooking smoke as households gradually shift to cleaner fuels. The international health community and government public health officials have an obligation, however, not to wait for the long run. The scientific evidence presented here and elsewhere clearly indicates that health hazards from indoor air pollution are a major public health problem that needs immediate attention. "The art and science of public health is in finding ways to make people healthy before they become wealthy."[xi]

Millions of people could be healthier if they had less exposure to biomass cooking smoke. Actions to reduce exposure include:

- Promoting use of cleaner fuels
- Educating people about the risks of exposure to cooking smoke
- Providing more efficient and better-ventilated cookstoves

Inexpensive but highly efficient cookstoves that use biomass fuels are an important part of an effective short-run strategy. There is ample evidence that even poor people are willing to pay (or at least help pay) for better stoves that improve their health. The most successful cookstove program has been in China, where some 200 million improved stoves have been

introduced in recent decades. The Chinese program demonstrates that a concerted action program can achieve remarkable results.

It is unlikely, however, that any single "magic stove" technology could solve the indoor air pollution problems in developing countries. Cookstove technologies must not only be acceptable technically and economically, but also accommodate people's social and cultural preferences regarding food availability and preparation.

While a number of programs have promoted better cookstoves, the effectiveness of these programs in reducing indoor air pollution is not well documented. Although several hundred programs in China, India, and elsewhere have promoted improved cookstoves, no independent systematic evaluation of their effectiveness has been conducted. Despite the lack of adequate evaluation research, there exists evidence that indoor pollution levels from biomass cookstoves currently in use remain extremely high, as indicated by a recent review published in the Bulletin of the World Health Organization.[iii]

Local needs and community participation must receive high priority

Although thousands of large and rigorous studies have measured how cigarette smoking affects health worldwide, only a few dozen studies have measured how cooking smoke affects health. Moreover, hardly any research has been done on the distribution and magnitude of exposure to cooking smoke in developing countries, and in spite of widespread use of biomass fuels and rising concerns about air pollution and deforestation, surprisingly few studies have attempted to assess the feasibility and cost-effectiveness of substituting biomass fuels with cleaner fuels.

Because indoor air pollution from cooking and heating is often worst in poor, remote, rural areas, it tends to receive less attention than more visible ambient air pollution in cities and other proximate health problems that catch public attention. Moreover, only a small fraction of biomass fuels are purchased through formal markets. Instead, people—mainly women and girls—gather fuelwood and other biomass in the countryside. Their energy-supply efforts do not show up on accounting ledgers or as commercial transactions. Thus use of biomass fuels is not adequately measured in national and international data collection efforts. For example, the International Energy Agency started listing biomass fuels in its annual compendia only in the late 1990s, and only at a high level of aggregation, lacking more detailed data.

Substitution of other fuels for biomass fuels is not without its own problems. Some governments have focused on biomass fuel use primarily in terms of its effect on depletion of forest resources, and in some countries proposals have been made to reduce pressures on forests by substituting coal for wood as fuel for use in homes. While such proposals could have potential environmental benefits, they also entail potential health hazards. Recent studies in China and South Africa, as well as earlier studies in the United Kingdom, have shown that indoor use of coal can lead to substantial health problems. One reason why China has one of the highest rates of lung cancer in the world for non-smoking women is the extensive use of coal for cooking and heating within homes.

In the short run, a major shift to cleaner and more energy-efficient cookstoves in poor, rural households in developing countries could substantially reduce the burden of ill health. Additionally, there is need for public information campaigns designed to inform people about the health risks of exposure to cooking smoke. For such programs to be effective, local needs and community participation should receive high priority. Programs that promote improved cookstoves and educate the public about adverse health effects of cooking smoke are an excellent government investment that can contribute not only to improved health but also to increased productivity and development goals.

Notes

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See also National Family Health Survey Bulletins at http://www2.eastwestcenter.org/pop/pop53001.htm

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