

Household Air Pollution from Cooking Fuels: An Environmental and Public Health Challenge

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Abstract: Cooking is central to our lives. Nearly 40% of the world population and about half of population of developing countries of Asia, Africa and Latin America rely on biomass fuels for their cooking energy needs and 84% of them reside in rural areas. When used in simple cooking stoves, these fuels emit substantial amounts of toxic pollutants that include respirable particles, carbon monoxide, oxides of nitrogen and sulfur, benzene, formaldehyde, 1,3-butadiene, and poly aromatic compounds. In households with limited ventilation as is common in rural household of developing countries, exposures experienced by household members have been measured to be many times higher than World Health Organization's indoor air quality guidelines. Due to customary role of woman in cooking, she is exposed more. As children are often carried on their mother's back or lap while the cooking is in progress, they are also exposed to high levels of cooking smoke and therefore are at risk of getting respiratory problems.

Research studies give moderate to strong evidence linking household air pollution with chronic lung and other diseases making it a major public health problem of poor nations where it accounts for much of morbidity and over a million deaths annually. Also, fuel gathering adds time and transport burden on women and children, limiting their time for education and other productive work. In addition to health risks, incomplete combustion of biomass fuels are also responsible for greenhouse gas emissions which are the key environmental concern for climate change today.

Key words: Household air pollution, biomass fuels, cooking, exposure, respiratory diseases.

Background

Smoke from cooking fuels is recognized as a significant source of potential health risks to exposed populations throughout the world. The most significant issue that concerns indoor air quality in household environments of developing countries is the exposure to pollutants released during combustion of solid fuels, including biomass (wood, dung, and crop residues) or coal used for cooking and heating. Most of rural households burn these simple solid fuels in inefficient earthen or metal stoves, or use open pits in poorly ventilated kitchens,

resulting in very high concentrations of household air pollutants. It is estimated that use of open fires with these fuels exposes people to enhanced concentrations of particulate matter and gases, up to 10-20 times higher than health-based guideline values available for typical urban outdoor concentrations (Barnes et al., 1994; Reddy et al., 1996; WHO, 1999). As a sizable population of the world cooks and heats their homes with biomass fuels on a daily basis (Smith, 1987); they are at risk of getting respiratory infections. For the year 2012, the World Health Organization (WHO) estimated that close to three billion people, mostly in low- and

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middle-income countries, lacked access to clean or modern energy services for cooking resulting in some 4.3 million premature deaths worldwide. Air pollution from household fuel combustion is the most important global environmental health risk today.

Cooking Fuel Use Scenario across the World

Over the last few decades, economic development and modernization has allowed households in wealthier parts of the world to switch to cleaner fuels such as petroleum products (e.g. kerosene, LPG) and electricity. Nearly 2.7 billion people—almost 40% of the world population and

about half of those living in developing countries of Asia, Africa and Latin America—rely on the traditional use of biomass fuels as the primary source of cooking energy and 84% of them reside in rural areas. Here, the issue is much more skewed towards developing Asia, which accounts for nearly 1.9 billion of the total number of people depending on biomass fuels for their day to day energy needs. India, alone, has more than 800 million people using inefficient, polluting means for cooking, larger in number than in the whole of sub-Saharan Africa (World Energy Outlook, 2014). Fuel use patterns across world regions are shown in Table 1.

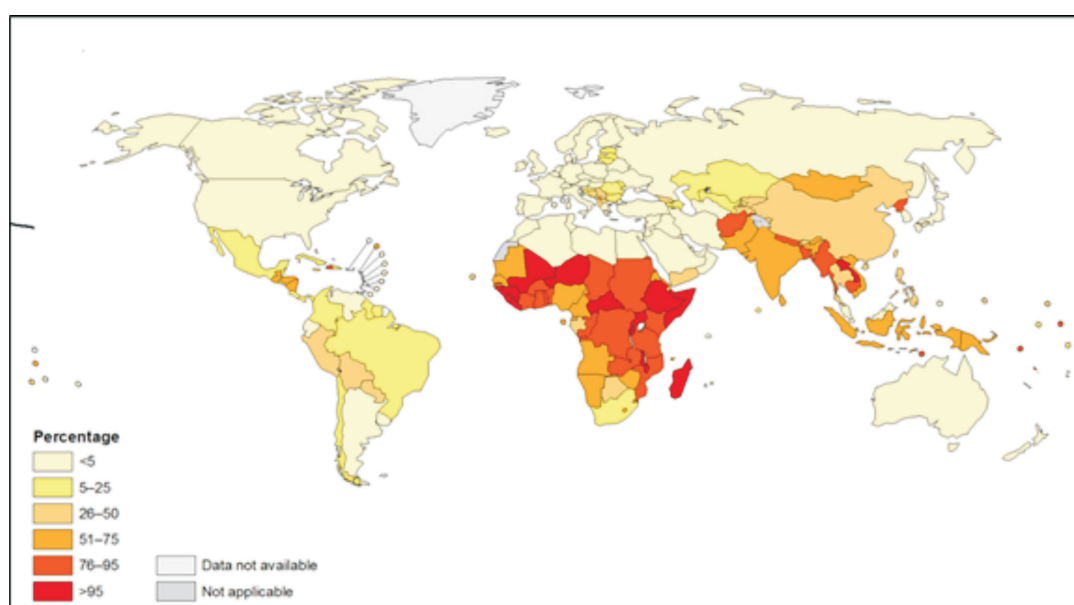


Figure 1: Household fuel use across world regions (Source: WHO, 2010).

Table1: Population relying on traditional use of biomass for cooking across world regions

Region	Population relying on use of biomass fuels (millions)	Percentage of population relying on use of biomass fuels (%)
Developing countries	2,679	49%
Africa	728	67%
Sub-Saharan Africa	727	80%
North Africa	1	1%
Developing Asia	1,875	51%
China	448	33%
India	815	66%
Latin America	68	15%
Brazil	13	6%
Middle East	8	4%
World	2,679	38%

Source: IEA, World Energy Outlook 2014.

Major Pollutants Emitted from Cooking Fuels

Combustion of biomass fuels in poorly vented kitchens using poorly functioning stoves leads to the release of very high concentrations of suspended particulate matter and noxious gases. These pollutants include respirable particles, carbon monoxide, oxides of nitrogen and sulfur, benzene, formaldehyde, 1,3-butadiene, and poly aromatic compounds, such as benzo(a) pyrene (Smith, 1987). Exposure to these pollutants has also been shown in several recent studies to be causally linked to several health effects especially among women who cook with these fuels (World Health Report, 2002). Some of these are carcinogenic in nature. A report of WHO asserts the rule of 1000 that states that a pollutant released indoor is 1000 times more likely to reach human lung than a pollutant released outdoor (Norboo, 1991).

The Vulnerable Group

People of the developing countries are typically exposed to very high levels of household air pollution for 3 to 7 hours a day (Engle et al., 1997). Some of the highest exposure to air pollutants occurs inside homes where biomass fuels are used for daily cooking (Dutt, 1996). Since it is mostly the women who cook daily household meals, their exposure is much higher than men's (Behera et al., 1988). Young children often accompany their mothers while she is cooking, resulting in spending many hours breathing smoke from early infancy (Albalak, 1997). Besides health risks, fuel gathering consumes a lot of time of women and children every day, limiting their other productive activities and taking children away from school. Therefore women and children constitute the most vulnerable group for household air pollution exposure.

Health Effects of Household Air Pollution

A number of studies have reported the health implications of household air pollution from biomass cooking. Several recent studies have shown strong associations between biomass fuel combustion and increased incidence of chronic bronchitis in women and acute respiratory infections among children in developing countries. According to WHO (2014) 4.3 million people a year die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels (2012 data). Among these deaths:

- 12% are due to pneumonia
- 34% from stroke

- 26% from ischaemic heart disease
- 22% from chronic obstructive pulmonary disease (COPD), and
- 6% from lung cancer.

Household Air Pollution and Acute Respiratory Infection in Children

Some of the earliest human evidence linking household air pollution from biomass combustion with respiratory health came from studies carried out in Nepal and India in the mid-1980s (Smith et al., 1983; Pandey, 1984; Ramakrishna et al., 1989). Since then, there has been a steady stream of studies, especially on women and young children (reviews may be found in Bruce et al., 2000; Smith et al., 2000c). Associations between exposure to household air pollution and increased incidence of chronic bronchitis in women and acute respiratory infections (ARI) in children have been documented (Armstrong and Campbell, 1991; Robin et al., 1996; Bruce et al., 1998; Ezzati and Kammen, 2001). Bruce et al. (2000) have reviewed existing evidence for the health impacts of household air pollution. There is evidence associating the use of biomass fuel with acute respiratory tract infections including pneumonia in children; this is potentially important because acute respiratory infections are the leading cause of death in children under the age of 5 (Smith et al., 2000c, 2004). Children exposed to household air pollution are between 2 to 5 times more likely to develop an acute respiratory infection such as pneumonia. Over half of deaths among children less than five years old from acute lower respiratory infections (ALRI) are due to particulate matter inhaled from indoor air pollution from household solid fuels (WHO, 2014).

Many studies conducted in rural Indian villages (Behera et al., 1991, Smith, 1993; Awasthi et al., 1996; Mishra and Retherford, 1997) and Parikh et al. (1999) examined the health implications of household air pollution with special reference to respiratory diseases among women and children in many states of India. Smith (2000b) presented a comprehensive methodology to estimate the health burden associated with household air pollution. As per the estimates reported in the study, about 0.5 to 2.0 million premature deaths per year in India could be attributed to household air pollution. Another study has characterized the exposure-response relationship between biomass smoke exposure and acute respiratory infection in children of rural Kenyan households (Ezzati et al., 2000).

Household Air Pollution and Chronic Obstructive Pulmonary Diseases

In addition to childhood acute respiratory infections, there is moderate to strong evidence linking household

air pollution with chronic lung disease and, in coal burning communities with lung cancer, in women. In industrialized countries, tobacco smoking accounts for over 80% of chronic obstructive pulmonary disease—the progressive and incompletely reversible obstruction of the airflow, such as chronic bronchitis (Norboo, 1991). However, in developing world this disease also occur in areas where tobacco smoking is rare. A woman who cooks over a biomass fire has between two to four times more chances of suffering from COPD than a woman who uses gas for cooking. The WHO estimates that 22% of all COPD is caused by exposure to household smoke from biomass fire. Incidence of cough, phlegm breathlessness, wheezing and eye irritation are also significantly higher in households using biomass fuels compared to those using gas for cooking (Diaz, 2007; Joon et al., 2014). The studies indicate that direct exposure of cook to particulate matter and CO was as high as 100 times in comparison to the WHO indoor air quality guidelines.

The incidence of chronic obstructive pulmonary disease (COPD) in non-smoking women using biomass for cooking has also been shown to be dependent on the number of years cooking with bio-mass and often found to be comparable to that of men (who usually have high smoking rates). The consistency of evidence from studies exclusively carried out in developing countries, together with supportive evidence provided by outdoor air pollution and environmental tobacco smoke studies indicates that there is likely to be a strong association between household smoke exposure and acute respiratory infections in children and chronic bronchitis in women.

Household Air Pollution and Other Diseases

In addition, evidence is now emerging of links with a number of other health conditions, including low birth weight, asthma, tuberculosis, cataracts and cancer of the upper airways (reviewed in Bruce et al., 2000). Exposure to nitrogen dioxide, sulphur dioxide and particles can pave the way for infection by bacteria or viruses by damaging the respiratory system's mechanical and immune defense. It increases the susceptibility of lung to pulmonary tuberculosis (TB). Person living in households burning biomass reported pulmonary TB more frequently than person using cleaner fuels with an odds ratio of 2.58 after adjustment for socioeconomic conditions (Bates et al., 2007). It is believed that the toxins from biomass fuel smoke are absorbed and accumulate in the lens of eyes resulting in its opacity, i.e., cataract. This is indicated by a study done by Smith in rural Nepal (Pokhrel et al., 2005). Similarly, Smith

et al. (2003) also reported evidence from China that exposure to coal smoke in the home markedly increases the risk of lung cancer, particularly in women.

Adverse pregnancy outcome (low birth weight and stillbirth) are the other conditions shown to be associated with the use of biomass fuel; low birth weight itself is a risk factor for prenatal mortality and Acute Respiratory Infections (ARI) among children below five years of age. In a study conducted in rural Guatemala babies born to women using wood fuel were 63 gm lighter than those born to mothers using LPG/electricity for cooking, after adjustment for socio-economic and maternal factors (Mishra et al., 2004).

According to WHO update 2014, nearly one quarter of all premature deaths due to stroke (i.e. about 1.4 million deaths of which half are in women) can be attributed to the chronic exposure to household air pollution caused by cooking with solid fuels. Similarly, approximately 15% of all deaths due to ischaemic heart disease, accounting for over a million premature deaths annually, can be attributed to exposure to household air pollution.

In addition, the use of biomass fuels for cooking and heating also puts household members, particularly children, at high risk of being burned (e.g. as a result of falling into fires, spilled fuel, etc.) and poisoning (caused by ingesting kerosene). However, other health impacts and discomforts such as backache, bruising, headaches and neckache resulting from collecting, transporting and processing of fuels are also important but have not received much attention of researchers. There is also a significant economic burden on the poor in terms of the equivalent number of work days spent on fuel collection, ranging from 3 to 7 days per month (Jyoti Parikh, 2011).

Table 2 shows relative risk estimates for health outcomes that are associated with exposure to smoke from solid fuel use (Smith, 2002).

Environmental Impacts of Household Air Pollution

In considering the environmental impact of energy use, greenhouse gas (GHG) emissions are a key concern.

Deforestation

The reliance on wood as a cooking fuel can put considerable pressure on forests, particularly in areas of fuel-wood scarcity. In such areas the demand for wood may outweigh natural re-growth of trees resulting in unsustainable wood harvesting leading to forest

Table 2: Health effects of exposure to household air pollution from cooking fuels and range of relative risk as reported by various researchers

<i>Health outcome</i>	<i>Population affected</i>	<i>Relative Risk</i>		<i>Strength of evidence</i>
		<i>Low</i>	<i>High</i>	
Acute lower respiratory infections (ALRI)	<5 years	2.0	3.0	Strong
Asthma	Females ≥ 15 years	1.4	2.5	Intermediate/moderate
Blindness (cataracts)	Females ≥ 15 years	1.3	1.6	Intermediate/moderate
Chronic obstructive pulmonary disease (COPD)	Females ≥ 15 years	2.0	4.0	Strong
Lung cancer (coal only)	Females ≥ 15 years	3.0	5.0	Strong
Tuberculosis	Females ≥ 15 years	1.5	3.0	Intermediate/moderate

Source: Smith, 2002

degradation. The loss of forest in turn may result in a consequent loss of habitat and biodiversity, degradation of soil and water resources of that region.

Climate Change

Household fuel combustion can have significant impacts on climate through both efficiency of combustion and the nature of the emissions. Traditional biomass stoves used in most of the low and middle income country households are inefficient. As a result, a large percentage of the energy is lost as products of incomplete combustion while burning these fuels. These products of incomplete combustion include powerful short-lived pollutants such as a black carbon and methane, which significantly contribute to the pool of greenhouse gases responsible for climate change. Black carbon is estimated to contribute the equivalent of 25 to 50% of carbon dioxide warming globally, and residential solid fuel burning accounts for up to 25% of global black carbon emissions. In South Asia, more than half of black carbon comes from the use of inefficient cook stoves. According to a publication by Ramanathan (2007), black carbon has been implicated as the second major contributor to global warming trends next to carbon dioxide. Black carbon also disrupts the monsoon and accelerates melting of the Himalayan-Tibetan glaciers. As a result, water availability and food security are threatened for millions of people (GACC, 2015).

Way Forward

Household air pollution is a multi-dimensional problem, and strategies to reduce its heavy toll on the health of rural families should integrate knowledge and perspectives from different sectors like Environment

and Forests, Rural Development, Women and Child Development, Health, Department of Science and Technology along with community participation. Studies also indicate that most of the solid fuel interventions promoted in recent years has not even come close to the levels suggested by WHO when in actual use. Therefore the exposure to the key pollutant—fine particulate matter or PM_{2.5}—needs to be brought down to low levels in order to gain most of the health benefit. Considering the extensive use of biomass fuels in the countryside and their potential health hazard, immediate measures such as introduction of smokeless chulah (oven with chimneys) and proper kitchen ventilation in all biomass using households, should be taken to reduce indoor air pollution level. Supply of cleaner fuel like LPG at an affordable price to the rural people should be promoted. Other clean fuel options for cooking such as solar cookers, biogas, briquettes and gasifier should also be explored for use in rural areas. Regular monitoring of health of the biomass fuel users and medical intervention for those diagnosed with respiratory health problems should be provided by the health sector. Extensive research on the mechanism of biomass-smoke toxicity and susceptibility is also required.

Conclusion

Household air pollution is a major public health problem of poor nations where it accounts for much of ill health and over a million deaths annually. Improved energy services can reduce child mortality rates, improve maternal health, and lessen the time and transport burden on women and young girls so that they have more time for education and other productive work.

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