Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 3, Issue 4; April-June, 2016, pp. 333-337

http://www.krishisanskriti.org/Publication.html

Indoor Air Pollution: A Major Environmental and Public Health Challenge in Developing Countries

Saroj Kumar Singh

Deptt. Of Rural Economics, S. N. S. R. K. S. College, Saharsa,
(A Constituent Unit of B. N. Mandal University, Madhepura, Bihar)
E-mail: drsaroj999@gmail.com

Abstract—*Indoor air pollution is a major global public health threat requiring greatly increased efforts in the areas of research and policy-making. Research on its health effects should be strengthened, particularly in relation to tuberculosis and acute lower respiratory infections. A more systematic approach to the development and evaluation of interventions is desirable, with clearer recognition of the interrelationships between poverty and dependence on polluting fuels. This paper tries to discuss what water pollution is and equally to address the source, affects and control measures and water pollution management with recommendations as a whole.*

Keywords*: air pollution, indoor – adverse effects; fossil fuels – toxicity; lung diseases; smoke inhalation injury; cataract; developing countries.*

1. INTRODUCTION

Indoor air pollution can be traced to prehistoric times when humans first moved to temperate climates and it became necessary to construct shelters and use fire inside them for cooking, warmth and light. Fire led to exposure to high levels of pollution, as evidenced by the soot found in prehistoric caves (1). Approximately half the world's population and up to 90% of rural households in developing countries still rely on unprocessed biomass fuels in the form of wood, dung and crop residues. These are typically burnt indoors in open fires or poorly functioning stoves. As a result there are high levels of air pollution, to which women, especially those responsible for cooking, and their young children, are most heavily exposed. In developed countries, modernization has been accompanied by a shift from biomass fuels such as wood to petroleum products and electricity. In developing countries, however, even where cleaner and more sophisticated fuels are available, households often continue to use simple biomass fuels. Although the proportion of global energy derived from biomass fuels fell from 50% in 1900 to around 13% in 2000, there is evidence that their use is now increasing among the poor. Poverty is one of the main barriers to the adoption of cleaner fuels. The slow pace of development in many countries suggests that biomass fuels will continue to be used by the poor for many decades. Notwithstanding the significance of exposure to indoor air pollution and the increased risk of acute respiratory infections in childhood, chronic obstructive pulmonary disease and lung cancer the health effects have been somewhat neglected by the research community, donors and policy-makers. We present new and emerging evidence for such effects, including the public health impact. We consider the prospects for interventions to reduce exposure, and identify priority issues for researchers and policy-makers. Biomass fuel is any material derived from plants or animals which is deliberately burnt by humans. Wood is the most common example, but the use of animal dung and crop residues is also widespread China, South Africa and some other countries also use coal extensively for domestic needs.

In general the types of fuel used become cleaner and more convenient, efficient and costly as people move up the energy ladder. Animal dung, on the lowest rung of this ladder, is succeeded by crop residues, wood, charcoal, kerosene, gas and electricity. People tend to move up the ladder as socioeconomic conditions improve. Other sources of indoor air pollution in developing countries include smoke from nearby houses, the burning of forests, agricultural land and household waste, the use of kerosene lamps, and industrial, and vehicle emissions. Indoor air pollution in the form of environmental tobacco smoke can be expected to increase in developing countries. It is worth noting that fires in open hearths and the smoke associated with them often have considerable practical value, for instance in insect control, lighting, the drying of food and fuel, and the flavouring of foods. Many of the substances in biomass smoke can damage human health. The most important are particles, carbon monoxide, nitrous oxides, sulphur oxides (principally from coal), formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[a]pyrene. Particles with diameters below 10 microns (PM10), and particularly those less than 2.5 microns in diameter (PM2.5), can penetrate deeply into the lungs and appear to have the greatest potential for damaging health.

The majority of households in developing countries burn biomass fuels in open fireplaces, consisting of such simple arrangements as three rocks, a U-shaped hole in a block of clay, or a pit in the ground, or in poorly functioning earth or metal stoves. Combustion is very incomplete in most of these stoves, resulting in substantial emissions which, in the presence of poor ventilation, produce very high levels of indoor pollution. Indoor concentrations of particles usually exceed guideline levels by a large margin: 24-hour mean PM10 levels are typically in the range 300–3000 mg/m3 and may reach 30 000 mg/m3 or more during periods of cooking.

The United States Environmental Protection Agency's standards for 24-hour average PM10 and PM2.5 concentrations are 150 mg/m3 and 65 mg/m3 respectively. The mean 24-hour levels of carbon monoxide in homes using biomass fuels in developing countries are in the range 2–50 ppm; during cooking, values of 10–500 ppm have been reported. The United States Environmental Protection Agency's 8-hour average carbon monoxide standard is 9ppm or 10 mg/m3.

A health effect is determined not just by the pollution level but also, and more importantly, by the time people spend breathing polluted air, i.e. the exposure level. A Exposure refers to the concentration of pollution in the immediate breathing environment during a specified period of time. This can be measured either directly through personal monitoring or indirectly by combining information on pollutant concentrations in each microenvironment where people spend time with information on activity patterns. Information on such patterns is very important for understanding the dynamic relationship between levels of pollution and behaviour. As pollution levels are reduced it is possible that people will spend more time indoors or nearer the sources of pollution. If this happens a reduction in ambient

Indoor air pollution in developing countries pollution will not necessarily result in a proportionate decrease in exposure, and there will be important implications for interventions. People in developing countries are commonly exposed to very high levels of pollution for 3–7 hours daily over many years. During winter in cold and mountainous areas, exposure may occur over a substantial portion of each 24-hour period. Because of their customary involvement in cooking, women's exposure is much higher than men's. Young children are often carried on their mothers' backs while cooking is in progress and therefore spend many hours breathing smoke.

We concentrate on exposure associated with the use of biomass fuel in populations of developing countries. However, where evidence is particularly limited, we include information concerning relevant exposures to outdoor and indoor air pollution and to environmental tobacco smoke. We consider respiratory illness, cancer, tuberculosis, perinatal outcomes including low birth weight, and eye disease.

2. RESPIRATORY ILLNESS

Childhood acute respiratory infections Acute lower respiratory infections. Acute lower respiratory infections are the single most important cause of mortality in children aged under 5 years, accounting for around 2 million deaths annually in this age group. Various studies in developing countries have reported on the association between exposure to indoor air pollution and acute lower respiratory infections. We restrict comment to the studies listed, as these have all used definitions of such infections which conform reasonably closely to current WHO criteria or to other definitions that were accepted at the time the studies were carried out and/or include radiographic evidence. A detailed review of this topic has recently been published.

Ten studies had case-control designs (two were mortality studies), four were cohort studies (all concerned with morbidity), and one was a case-fatality study. Whereas acute lower respiratory infections were relatively robustly defined, the measurement of exposure relied in almost all studies on proxies, including the types of fuel and stove, whether a child stayed in the smoke and whether it was carried on the mother's back while cooking was in progress, and reported hours spent near the stove. In the only study in which direct measurements were made of pollution and exposure in a subsample, respirable particles in the kitchens of cases were substantially higher than for controls (1998 mg/m3 versus 546 mg/ m3; $p < 0.01$) but there was no significant difference in carboxyhaemoglobin levels.

Five studies reported no significant association between the incidence of acute lower respiratory infections and exposure, but the remainder reported significantly elevated odds ratios in the range 2–5 for incidence or deaths. Not all, however, dealt adequately with confounding factors, although accounting for confounding in studies of this exposure may in any case be problematic. However, odds ratios in studies that adjusted for confounding were similar in range to those in unadjusted studies. In several studies in which no association was found, relatively small proportions of the samples were exposed. In urban Brazil, for instance, only 6% of children were exposed to indoor smoke; in another South American study, 97% of homes used gas for cooking, although 81% used polluting fuels for heating, namely kerosene, wood and coal. In the latter study, neonates with a birth weight below 2500 g — the group most vulnerable to acute lower respiratory infections — were excluded. In Durban only 19% of cases and 14% of controls used wood or coal stoves. A so-called smokeless chullah (mud hearth) was used in one study as an indicator of lower exposure, but such stoves can be little better than traditional ones.

Studies in Navajo communities used case control designs, reported fuel type (wood versus cleaner) as a proxy for exposure and adjusted for confounding. They reported elevated odds ratios of approximately 5, although these were not statistically significant in one of the studies. The latter study also involved measuring 15-hour PM10 levels: there were minimal differences between cases and controls, and the actual levels (median 15-hour PM10 = 22.4 mg/m3, range 3.2–186.5 mg/m3) were relatively low. However, children living in homes with PM10 levels of 65 mg/m3 and above had an odds ratio that was 7.0 times higher than for children with levels below 65mg/m3 (95% confidence interval=0.9–56.9).

Upper respiratory infection and otitis media. Several studies have reported an association between exposure to biomass fuel smoke and general acute respiratory illness in children, mostly of the upper respiratory tract. Middle ear infection (otitis media) is rarely fatal but causes much morbidity, including deafness, and makes demands on the health system. Untreated, it may progress to mastoiditis. Evidence from developing countries is very limited, but there is good reason to expect an association. There is strong evidence that exposure to environmental tobacco smoke causes middle ear disease: a recent meta-analysis reported an odds ratio of 1.48 (1.08–2.04) for recurrent otitis media if either parent smoked, and one of 1.38 (1.23–1.55) for middle ear effusion in the same circumstances. A clinic-based case-control study of children in rural New York State reported an adjusted odds ratio for otitis media, involving two or more separate episodes, of 1.73 (1.03–2.89) for exposure to wood-burning stoves.

3. CHRONIC PULMONARY DISEASE

In developed countries, smoking is responsible for over 80% of cases of chronic bronchitis, i.e. inflammation of the lining of the bronchial tubes, and for most cases of emphysema (over inflation of the air sacs in the lungs) and chronic obstructive pulmonary disease (progressive and incompletely reversible airflow obstruction). However, these diseases occur in regions where smoking is infrequent. Patients with chronic lung disease have been reported in communities heavily exposed to indoor biomass smoke pollution in New Guinea.

Tobacco smoke is the most important risk for lung cancer and explains most cases in industrialized countries. In developing countries, non-smokers, frequently women, form a much larger proportion of patients with lung cancer. Some two-thirds of women with lung cancer in China, India and Mexico were non-smokers. In China, odds ratios for lung cancer among women exposed to coal smoke at home, particularly that of so-called smoky coal, were in the range 2–6. Smoky coal has been found Bulletin of the World Health Organization, 2000, 78 (9) 1083

4. INDOOR AIR POLLUTION IN DEVELOPING COUNTRIES

To be more carcinogenic than cleaner coal and wood smoke when tested on mouse skin (97). Noassociation has been reported between lung cancer and exposure to wood smoke (95). Rates of lung cancer in rural areas, where such exposure is common, tend to be low. This could be attributable to various factors associated with the rural environment, and it would be unwise to conclude that biomass smoke does not increase the risk of lung cancer, especially as there is intense exposure to known carcinogens in biomass smoke. In some homes, cooking for three hours per day exposes women to similar amounts of benzo[a]pyene as smoking two packets of cigarettes daily. If exposure to all carcinogens in wood smoke parallels exposure to particles, cooking with traditional biomass stoves is equivalent to smoking several cigarettes per day.

A history of previous lung disease is a risk factor for lung cancer in women. In developing countries, previous lung disease attributable to tuberculosis and other lung infections could contribute to lung cancer development in persons who have never smoked. Chronic obstructive pulmonary disease is associated with an increase in cancer risk, even when age, sex, occupation and smoking are taken into account. This suggests either that there is a parallel exposure to lung toxins and carcinogens or that chronically inflamed or injured tissue is more prone than normal tissue to develop cancer. Whatever the mechanism, exposure to biomass smoke is a potential risk factor for lung cancer.

5. NASOPHARYNGEAL AND LARYNGEAL CANCER

Biomass smoke has been implicated as a cause of nasopharyngeal carcinoma, although this is not a consistent finding. A case-control study in Brazil found that oral cancer was associated with tobacco, alcohol and the use of wood stoves.

Another case-control study from South America of 784 cases of oral, pharyngeal and laryngeal cancer reported an adjusted odds ratio of 2.68 (95% confidence interval = 2.2–3.3) for exposure to wood smoke as compared with cleaner fuels.

Significant associations were demonstrated separately for mouth, laryngeal and pharyngeal carcinomas and it was estimated that exposure to wood smoke explained about a third of upper aero-digestive tract cancers in the region.

6. PULMONARY TUBERCULOSIS

An analysis of data on 200 000 Indian adults found an association between self-reported tuberculosis and exposure to wood smoke. Persons living in households burning biomass reported tuberculosis more frequently than persons using cleaner fuels, with an odds ratio of 2.58 (1.98–3.37) after adjustment for a range of socioeconomic factors.

These findings were similar to those of a study in north India, which reported an association between the use of biomass fuel and tuberculosis defined by clinical measures, although adjustment was made only for age.

This effect of wood smoke may result from reduced resistance to lung infection. Exposure to smoke interferes with the mucociliary defences of the lungs and decreases several antibacterial properties of lung macrophages, such as adherence to glass, phagocytic rate and the number of bacteria phagocytosed. Chronic exposure to tobacco smoke also decreases cellular immunity, antibody production and local bronchial immunity, and there is increased susceptibility to infection and cancer. Indeed, tobacco smoke has been associated with tuberculosis. Although such widespread immunosuppression has not been reported with biomass smoke, an increase in the risk of tuberculosis is quite conceivable.

This association, if confirmed, would have substantial implications for public health. Exposure to biomass smoke can explain about 59% of rural cases and 23% of urban cases of tuberculosis in India. Such exposure may be an additional factor in the relationship between poverty and tuberculosis, hitherto explained by malnutrition, overcrowding and inadequate access to health care.

7. CATARACT

Pollution attributable to the use of biomass fuel causes eye irritation and may cause cataract. In a hospital-based case-control study in Delhi the use of liquefied petroleum gas was associated with an adjusted odds ratio of 0.62 (0.4–0.98) for cortical, nuclear and mixed, but not posterior sub-capsular cataracts in comparison with the use of cow dung and wood. An analysis of over 170 000 people in India yielded an adjusted odds ratio for reported partial or complete blindness of 1.32 (1.16– 1.50) in respect of persons using mainly biomass fuel compared with other fuels, and there were significant differences between men and women and between urban and rural residents. Adjustment was made for a number of socioeconomic, housing and geographical variables, although there was a lack of information on smoking, nutritional state, episodes of diarrhea and other factors that might have influenced the prevalence of cataract. On the other hand, the crude method of classifying exposure could be expected to result in an underestimation of the effect.

8. PROSPECTS FOR INTERVENTIONS

The goal of interventions should be to reduce exposure to indoor air pollution, while meeting domestic energy and cultural needs and improving safety, fuel efficiency and environmental protection.

Interventions should be affordable, perhaps requiring income generation and credit arrangements, and they should be sustainable. The evaluation of interventions should take into consideration all these criteria in addition to emphasizing the importance of reducing exposure to indoor air pollution.

9. CONCLUSION

Indoor air pollution is a major public health hazard for large numbers of the world’s poorest, most vulnerable people and may be responsible for a similar proportion of the global burden of disease as risk factors such as tobacco and unsafe sex. The greatest contribution to this burden results from childhood acute lower respiratory infections. The evidence on which these estimates are based, however, is rather limited. It is Bulletin of the World Health Organization, 2000, 78 (9) 1087 important to extend and strengthen it, particularly for the most common and serious conditions including acute lower respiratory infections and tuberculosis, to quantify exposure, and to ensure that confounding is adequately dealt with. A few well-conducted randomized controlled studies on the health impact of reducing exposure would markedly strengthen the evidence, and should be feasible at the household level. For conditions where the evidence is very limited (e.g. low birth weight) or where a long latent period would make an intervention study impractical (e.g. tuberculosis, cataract), further observational studies are desirable.

Although work on interventions to reduce exposure has given mixed results, there is a wide range of possibilities and there has been some success in terms of both exposure reduction and uptake. The development and evaluation of interventions should take account of the many aspects of household energy supply and utilization, and should include assessment of pollution and exposure reductions, fuel efficiency, and impact on the local and global environment, safety, capacity to meet household needs, affordability, and sustainability. There is a need for a coordinated set of community studies to develop and evaluate interventions in a variety of settings, together with policy and macroeconomic studies on issues at the national level, such as fuel pricing incentives and other ways of increasing access by the poor to cleaner fuels. Also required is a systematic, standardized approach to monitoring levels and trends of exposure in a representative range of poor rural and urban populations.

Finally, it is necessary to keep in mind the close interrelationship between poverty and dependence on polluting fuels, and consequently the importance of socioeconomic development, which should be at the core of efforts to achieve healthier household environments.

REFERENCES

[1] Smith KR. 1987, Biomass fuels, air pollution, and health. *A global review.* New York, Plenum Press.

[2] Smith KR 1994, et al. *Air pollution and the energy ladder in Asian cities.* Energy, 19: 587–600.

[3] Martin KS. 1991, *Indoor air pollution in developing countries.* Lancet, 337: 358.

[4] Norboo 1991, T et al. Domestic pollution and respiratory illness in a Himalayan village. *International Journal of Epidemiology,* 20: 749–757.

[5] Saksena S 1992, et al. Patterns of daily exposure to TSP and CO in the Garhwal Himalaya. *Atmospheric Environment*, 26A: 2125–2134.

[6] Smith K. 1989, Dialectics of improved stoves. *Economic and Political Weekly,* 11: 517–522.

[7] Strachan D. P, Cook D. G.1998, *Parental smoking, middle ear disease and adenotonsillectomy in children.* Thorax, 53: 50–56.

[8] Daigler G. E, Markello S. J, Cummings K. M. 1991, *The effect of indoor air pollutants on otitis media and asthma in children.* Laryngoscope, 101: 293–296.

[9] Anderson H. R. 1979, *Chronic lung disease in the Papua New Guinea highlands.* Thorax, 34: 647–653.

[10] Padmavati S, Pathak S. N. 1959, *Chronic cor pulmonale in Delhi.* Circulation, 20: 343–352.

[11] Bjorksten B. 1999, *The environmental influence on childhood asthma. Allergy,* 54 (Suppl. 49): 17–23.

[12] Strachan D. P, Cook D. G. 1998, *Parental smoking and allergic sensitization in children.* Thorax, 53: 117–123.