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Review Article

Household Air pollution due to Biomass smoke exposure and Chronic Obstructive Pulmonary Disease

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Summary

Chronic Obstructive Pulmonary Disease (COPD) is an important non communicable disease with rising morbidity and mortality worldwide. This results in an economic and social burden, and hence is a major public health concern. COPD is predicted to be the third commonest cause of death by 2030. Tobacco smoking is the main risk factor for COPD in developed countries. In developing countries like India, women exposed to biomass smoke are at a greater risk of developing COPD but the awareness of biomass smoke exposure associated COPD in women, is low among treating physicians. The aim of this review is to increase awareness about the extent of household air pollution caused by biomass smoke and its impact on women leading to COPD.

Keywords: COPD (Chronic Obstructive Pulmonary Disease), BS (Biomass Smoke), Household Air Pollution.

1. Biomass use and Burden of Disease

Biomass fuel consists of wood, dried animal dung, crop residue, leaves, twigs and charcoal (product of incomplete burning of wood) which is cheap and easily available. It is estimated that one half of the world's population, approximately 3 billion people worldwide use biomass fuel for cooking and heating purpose, 2.4 billion burn biomass and 0.4 billion use coal[1]. These 3 billion are at risk of adverse health effects due to exposure to biomass smoke. 90% of rural population of the world and 75% of Indian population (700 million people) use biomass fuel for cooking and heating purposes[2]. 75% of rural homes and 22% urban homes in India use biomass fuel[3]. India (27%) and China (25%) together account for half the global population that uses biomass fuels for cooking. The use of biomass fuel depends on socio-economic status, availability of biomass, unavailability of cleaner fuels like electricity or LPG, traditions, non availability of cooking space to burn biomass fuel in urban households and awareness. Highest exposures to indoor air pollution occur during burning of biomass fuel during the cooking process. Women who are the principal cooks of the family, young children being cared by their mothers (carried by mothers on their backs during cooking) and elderly people found indoors are mostly exposed[4].

By 2030 when COPD will rank the third commonest cause of death, 54% of Indian population and 52% of other Asian countries will be still using traditional biomass fuels.[5]. The World Health Organisation estimates that outdoor air pollution accounts for 5% of deaths worldwide, 1.3 million deaths per year and indoor air pollution contributes to 2 million premature deaths with more than 99% occurring in developing countries[6]. Of these, 44% are due to pneumonia, 54% from COPD and 2% from lung cancer. Biomass fuel attributes to 5-6% of the national burden of disease in India[7] and tops in the fuel related deaths in South Asian region [8]. With rising cost of fuel even some developed countries like Canada, Australia and western states of the United States are resorting to use of biomass as fuel[9].

2. Component of Biomass Fuel Smoke

Worldwide wood is the most commonly used biomass fuel. More than 2 billion kg of biomass is burnt everyday in open fires and inefficient cookstoves[10]. The biomass smoke also contributes to outdoor air pollution. Wood smoke released during incomplete combustion is a complex mixture of various volatile and respirable particulate substances derived from wood polymers and resins. More than 200 chemicals and compound groups are identified and >90% of these are in the respirable size range[11]. Biomass smoke constituents are known to be toxic or have irritant effect on respiratory tract. They include particulate matter < 10 microns in aerodynamic diameter (PM_{10}) and 2.5 microns (PM 2.5), carbon monoxide (CO), nitrogen dioxide, sulfur dioxide, aldehydes (formaldehyde), polycyclic aromatic hydrocarbons (benzopyrene), volatile organic compounds, chlorinated dioxins and free radicals. When coal is used, sulfur, arsenic and fluorine may also be present in the smoke.

Amongst these PM10 has significant adverse health effects and in homes using biomass fuel, the mean 24 hrs PM10 levels reach as high as 300 – 3000 ug/m^3 with peak reaching 20,000ug/m^3 during cooking. The safety standard set by US Environment Protection Agency (EPA) for 24 hour average PM10 exposure should not exceed 50ug/m^3 and annual mean not exceeding 20ug/m3[12]. Thus indoor air pollution due to biomass fuel use is 10 – 70 times above those observed in the most polluted cities of the world. The mean carbon monoxide concentrations in homes using biomass fuel is in the range of 2 – 50ppm (parts per million) which can increase to 500ppm during cooking. The safety standard for CO for 8 hours is < 9ppm. Individual exposures are influenced by fuel type, stove type, kitchen type (indoor/ outdoor), ventilation in kitchen and duration of cooking.The exposure is significantly lower for those using open outdoor kitchens due to dispersion of smoke. Homes having kitchen indoors without partition, have high concentrations of pollutants in living room areas exposing other members of the family to toxic effects of biomass smoke.

The solid biomass fuels have low energy conversion efficiency ranging from 12% to 25%. Crop residue, dung (12%), wood containing 15% moisture (15%), charcoal burnt in traditional stoves (20%), bituminous coal (25%), kerosene used in wick stoves (35%) and pressure stoves

(55%) while LPG energy conversion is 60%[13]. However due to socio economic reasons people use easily available and cheap biomass fuel for cooking and heating purposes.

2.1 Health effects of Biomass Smoke Exposure

There is limited data on how biomass smoke affects lungs. In animal studies, rats exposed to chronic wood smoke develop epithelial cell hyperplasia and hypertrophy, mild bronchiolitis, alveolar septal wall thickening and emphysema[14]. Rat exposed to wood smoke at 1 – 10 mg/m3 over weeks show reduced carbon monoxide diffusing capacity, increased airway resistance, mild chronic inflammation and squamous metaplasia in larynx, alveolar macrophage hyperplasia and thickening of alveolar septa[15].

Bronchoalveolar lavage study in healthy human volunteers acutely exposed to wood smoke reveals a neutrophilic influx[16]. Macrophage dysfunction, greater gene expression of matrix metalloproteinases (MMP), increased proteolytic activity of MMP, pulmonary surfactant deactivation; reduced bacterial clearance and reduced mucociliary clearance are reported [17]. Solid fuel smoke produces DNA damage and inflammatory and oxidative stress response gene expression in cultured human cells[18]. Biomass smoke inhalation causes oxidative stress and DNA damage in lungs and it is said to be the possible mechanism for pathogenesis of COPD[19]. Indian study by Pandey et al also demonstrated DNA damage in lymphocytes of women exposed to biomass smoke and impaired macrophage function [20]

Particulate matter PM10 and PM 2.5 can be inhaled deeply into the lungs. The pathology due to biomass smoke exposure leads to respiratory tract infections, wheezing, chronic bronchitis and chronic obstructive pulmonary diseases. The determination of the concentration of suspended particles in home offers the best indicator of the health risk. The next component, carbon monoxide combines with hemoglobin to form carboxyhaemoglobin with reduced delivery of oxygen to tissues and developing fetus. This leads to low birth weight babies and increases perinatal deaths. A short term effect of carbon monoxide causes headache, nausea and dizziness. Polyaromatic hydrocarbon benzopyrene is a carcinogenic substance and is known to cause lung cancer, cancer of mouth, nasopharynx and larynx. Formaldehyde causes irritation of nasopharynx and airways while nitrogen dioxide and sulphur dioxide increases bronchial reactivity leading to wheezing, repeated respiratory tract infections and exacerbations of asthma. Absorption of toxins from biomass smoke into the eye lens causes oxidative changes leading to cataract in some individuals.

2.2 Biomass smoke exposure as a risk factor for Chronic Obstructive Pulmonary Disease

COPD is a heterogeneous disease. Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines, defines it as a common preventable and treatable disease characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and lung to noxious particles and gases[21]. Pathologically it is a small airway disease with airway inflammation, destruction of lung parenchyma and loss of alveolar attachments. GOLD guidelines recognizes biomass smoke exposure as a risk factor for COPD and advises physicians to probe for this risk factor.

Traditionally women undertake routine cooking for the family. Being the primary cook of the family, women using biomass fuel for cooking are exposed to indoor air pollutants for prolonged periods and for many years as compared to men living in the same household[22]. The biggest risk factor for COPD is tobacco smoking in developed countries. In a developing country like India where the prevalence of smoking is low in women (3.6% in women and 26.25% in men) [23], we find the prevalence of COPD to be equal in men and women (2-22% in men, 1.2 - 19% in women.)[24]. Biomass smoke exposure is the main risk factor for COPD in women. Women begin cooking at an early age and so have a higher cumulative exposure leading to early manifestation of the disease. In a meta analysis by Kurmi et al, pooled estimates by fuel type showed that wood smoke (OR=4.29, 95% CI 1.35 to 13.70) is the most important risk factor for COPD followed by mixed biomass smoke (OR =2.49, 95% CI 1.54 to 4.01) and coal (OR=1.84, 95% CI 1.01 to 3.35)[25]. The degree of risk is related to the concentration of pollutants which depends on duration of exposure, type of kitchen, ventilation in the kitchen and living room area air pollution.

It is noted that tobacco smoke potentiates the development of COPD in individuals exposed to biomass smoke[26]. An additive interaction between wood smoke and cigarette exposures on COPD are also described[27].

Women with biomass smoke associated COPD have similar clinical presentation as tobacco smoke associated COPD[28]. Hence a non smoking women presenting with cough, sputum and dyspnea should be investigated for possible COPD. Early diagnosis and treatment will provide a better quality of life to the patient and also decrease mortality and morbidity associated with this disease.

2.3 How to reduce exposure to biomass smoke

The best and effective way of eliminating exposure to biomass smoke is to shift to cleaner fuels like electricity or LPG (Liquefied Petroleum Gas) but this is not always feasible. Use of improved (smokeless) stoves reduce the level of indoor air pollution but does not totally eliminate the pollution. The improved cook stoves require lesser biomass fuel as their combustion efficiency is higher. This leads to lesser deforestation. Time spent in collecting wood by the women is also reduced. The women can thus spend quality time with their family. This also benefits children who are often involved in helping their mothers collect wood.

WHO is a leading partner in a new Global Alliance for clean cook stoves led by United Nation Foundation. The alliance is promoting improved biomass cookstove designs and biogas stoves. One intervention study done in Guatemala using improved cook stove with chimney showed a significant reduction in chronic respiratory symptoms in those using improved cook stoves compared to the control group using open indoor fires[29].When improved cook stoves cannot be used or are not available, improving home ventilation, partitioning the kitchen from living room or cooking outdoor can reduce exposure to biomass smoke.

3. Conclusions

Biomass smoke exposure related diseases are common in rural population and in individuals using biomass fuel in urban areas. This increases the burden of diseases in our country. Providing health education on indoor air pollution, using cleaner cook stoves or cleaner fuels can prevent biomass smoke related diseases and eventually prevent COPD which is a huge economic burden to our country. Creating physician awareness of biomass smoke associated COPD can help detect the disease early and provide a better quality of life to COPD patients.

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