International Scholars Journals

African Journal of Environmental and Waste Management ISSN: 2375-1266 Vol. 2 (6), pp. 151-157, June, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

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Full length research paper

An investigation of risk factors associated with indoor air pollution in the low-income households of Aligarh city, India

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Accepted 4 May, 2015

This paper seeks to investigate the risk factors associated with indoor air pollution in low income households. Cooking with traditional fuels leads to high levels of indoor air pollution, exposure of which increases the risk of various health problems. This study is based on primary sources of data collected with the help of questionnaire interviews from 533 low income households (earning Rs.5, 000 and less per month). Since women are responsible for cooking they were selected as respondents. This study investigates the major socio-economic factors including housing and cooking conditions, identification of risk factors and occurrence of associated diseases. The results show that most of the low income households were using traditional fuels and stoves, cooking in multipurpose room and *VERANDA*, in poorly ventilated cooking places and taking long hours for cooking. Thus, they were exposed to all the associated risk factors of indoor air pollution. They reported of the occurrence of associated diseases, like acute upper and lower respiratory infections, chronic obstructive pulmonary disease, asthma, perinatal mortality, pulmonary tuberculosis, low birth weight, eye irritation and cataract etc. The study points to the need of creating awareness amongst the low income households.

Keywords: Indoor air pollution; traditional fuels; risk factors; diseases.

INTRODUCTION

The provision of air that is safe to breathe is just as important as safe water or food. When most people think of air pollution, they think of outdoor air pollution – smokestacks, spouting grey clouds of smoke or choking exhaust from vehicles. Indoor air pollution, the source of pollution with the greatest health consequences, remains unseen (Down to Earth, March 31, 1999). In terms of environmental risks, indoor air pollution is the second most important risk factor, after unsafe water. It accounts for twice the number of deaths reported from urban outdoor air pollution (Down to Earth, July 15, 2007). According to recent findings, indoor air pollution is five times more hazardous than outdoor air pollution and the major source, the solid fuels is the second most environmental cause of disease after water-borne disease and fourth most important of overall excess mortality and burden of diseases (WHO, 2002). Yet many millions of people, predominantly women and children in the developing countries, are obliged to breathe the air that is heavily polluted with biomass emission products.

Indoor air pollution is recognized as a significant source of potential health risk to exposed populations throughout the world. The major source of indoor air pollution worldwide includes combustion of fuels, tobacco and coal; ventilation systems; furnishing and construction material. The most significant issue that concerns indoor air quality in household environment is that of exposure to pollutants released during combustion of solid fuels, including biomass or coal used for cooking and heating. Most of the households using these fuels burn in inefficient earthen/metal stoves or in *chulhas* ('U' shaped stoves made of mud and brick) in poorly ventilated kitchens resulting in very high concentrations of indoor air pollutants. Inadequate ventilation can increase the level of indoor pollutants by not bringing in enough outdoor air to dilute the indoor air and by not carrying indoor air pollutants out of the home. In our country indoor air pollution studies particularly in urban households has so far been neglected. Recent estimates have shown that 82

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per cent of sulphur dioxide (SO2), 38 per cent of nitrogen dioxide (NO2), 88 per cent of volatile organic compounds and 96 per cent particulate matter emissions in the country come from the household sector (Parikh, 1999).

Choices of cooking fuel directly influence the level of indoor air quality. It reflects household's preference towards the environment. A wide variation in use of type of cooking fuel, stoves is also spectacular in different income strata due to which level of exposure also varies which has been specified by the number of researchers using the energy ladder model (Baldwin, 1986; Hosier & Dowd, 1988; Smith, 1987; Leach, 1992). The energy ladder model has been derived from the empirical evidences; so-called modern fuels are increasingly being used as household income increases in urban areas. Preferences for switching include convenience in obtaining, storing, and using the fuels (cleanliness, versatility and a large and easily controlled range of power output) (Leach, 1988) and lower fuel costs (Reddy & Reddy, 1994). In extreme interpretation, the process of fuel switching (termed fuel transition) has been equated with a ``development path'' (Smith, 1987). According to this view, households using different fuels belong to different ``development levels,'' at the bottom of the scale are fuel wood users, and at the top electricity users.

Air pollution is a significant cause of morbidity and mortality. The greatest health impacts from air pollution worldwide occur among the poorest and most vulnerable populations. The amount of exposure in terms of the number of people, exposure intensity and time spent is far greater in developing world (Smith, 1993). Many of the substances in biomass smoke can damage human health. The most important are particles, carbon monoxide, nitrogen oxides, sulphur oxides, formaldehyde and polycyclic organic matter, including carcinogens, such as benzo (a) pyrene (De, Koning, et al, 1985). Particles with diameters below 10 microns (PM_{10}) and particularly those less than 2.5 microns ($PM_{2.5}$) are small enough to penetrate deeply into the lungs and appear to have greatest potential for damaging health (USEPA, 1997). Indoor air pollution mostly affects health through inhalation, but can also affect the eyes through contact with smoke. Indoor air pollution contributes to nearly 3 million deaths annually and 4 per cent of the global burden of disease. Despite the magnitude of this growing problem, the health impacts of exposure to indoor air pollution have yet to become a central focus of research. Keeping these aspects in mind, in this paper an attempt has been made to examine the risk factors associated to indoor air pollution in the low income households in Aligarh city.

MATERIALS AND METHODS

The study is mainly based on primary sources of data collected through surveys of 533 low income households with the help of questionnaire interviews. Field work was conducted during the years 2009-10. Following methods were adopted for this study,

For selecting the sample, multistage stratified sampling design was acquired. In the first stage 14 wards (20 per cent) were selected from the city's 70 wards on the basis of their location (5 wards from the old city, 3 wards from the new city and 6 wards from the fringe areas of the city), for getting accurate information of the whole city, (figure.1). The second stage consisted of selection of low income households (having an income of less than Rs. 5,000 per month (1US$= Rs. 45.2)) from each of the selected wards. About 35 to 40 low income households were selected from each ward. From each household a senior woman was chosen as the respondent because women are more involved in their household activities so they know more about their household conditions. The total sample size consisted of 533 low income households.

A questionnaire was prepared with the help of questionnaires used in similar studies (Smith, 1990, 2000; Lioy, 1990; Bruce, Prez-Padilla and Albalak, 2000; Ezzati and Kammen, 2001; Singh, 2002-2003) and keeping in mind the objectives of the study. Information regarding the socio-economic and housing conditions, type of fuel used for cooking (traditional/modern/both), place of cooking food, types of exposures (exposure to smoke, heat/high temperature) and occurrence of associated specific diseases was collected (to obtain an overall view, data was also collected from the Out Patient Departments of Jawahar Lal Nehru Medical College Hospital, Malkhan Singh Government Hospital, Mohan Lal Gautam Women's Government Hospital and various private doctors clinics of Aligarh city). Risk factors associated to indoor air pollution were identified; data regarding the occurrence of specific diseases was collected.

RESULTS AND DISCUSSION

Aligarh city (27°53' latitude and 78°4'E longitude) a medium sized city located in the fertile Gangetic plain of North India, was chosen as the study area. The total area of the city is 36.7 sq. km and its population is 669,087 (Census of India, 2001). Of the 70 wards of Aligarh city, 21 wards are low income wards (Aligarh Municipal Corporation, 2010). From the 14 wards, 533 low income households were selected for gathering information.

Socio-economic conditions of the sampled households

Income determines man's way of living, location of residence, type of house and access to various amenities and facilities. The information gathered from low income household surveys with the help of questionnaire interviews is presented in table 1. A perusal of table 1

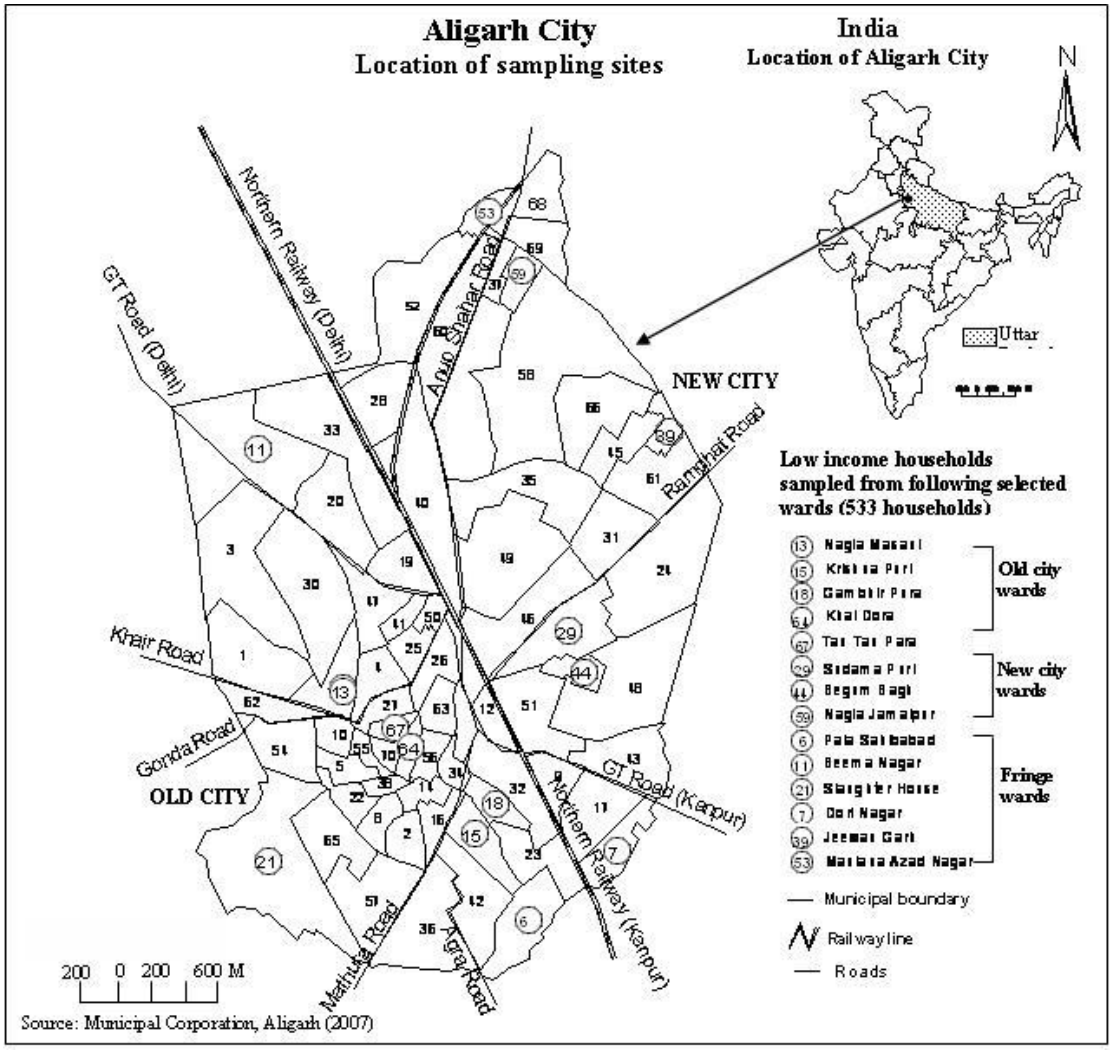

Figure 1: Aligarh City

shows that the total sampled low income households (533) belong to the low socio-economic strata (earning <Rs. 5,000 per month), caste (mostly belonging to scheduled caste (52 per cent) and other backward caste (37 per cent)). Most of them were uneducated (88 per cent) and unemployed (67 per cent). An educated household will be aware about indoor air pollution and will always think of using clean cooking fuels emitting less pollutants. Only very few were educated (12 per cent) up to primary or middle level and employed (61 per cent) in the informal sectors (as lock labourers, construction labourers, rickshaw/trolley pullers, domestic workers, vegetable sellers, petty shop keepers etc.) which is characterised by low incomes, long hours of work and low wages.

Regarding their housing condition, it was observed that mostly they were living in mixed (both *pucca* and *kutcha*) type of houses (39 per cent), and rest in *kutcha* (26 per cent) houses. That is nearly three fourth of the sample were living in sub standard houses, having leaky thatched roofs, with mud or brick walls etc. *Kutcha* roof retains the smoke inside the room for longer duration. Only one quarter were living in *pucca* (cemented) houses. Three fourth of the households were living in more than 1 room while rest (29 per cent) lived in 1 room houses. Usually 1 or 2 families were found to be living in one house (52 per cent) while in rest (48 per cent) more than 2 families were living. Three fourth of the sample had 6 or more than 6 children per family. This showed crowding and congestion in the homes. The house did not have proper ventilation. It has been observed that there was crowding / congestion in their homes because of large family size and more than one family living in one house, which aggravates the occurrence of associated diseases.

From the total low income sampled households, most of them were cooking food in the *veranda* (40 per cent), in the multipurpose room (31 per cent) and in the open air

T**able 1:** Distribution of low income sampled households (in percentages) according to their socio-economic, housing and cooking conditions

	Conditions	Types	Percentages
	Caste	General	35.41
		OBC	37.7
Total low income households 533		SC	26.89
	Educational status	Educated	12.2
		Uneducated	87.8
income less than Rs. 5,000 per month	Occupational status	Employed	36.02
		Unemployed	63.98
	House type	*Kutcha*	26.08
		Pucca	35.27
		Mixed	38.65
	Number of rooms	1 room	29.27
		More than 1 room	70.73
	Number of families living in a house	1—2	52.35
		More than 2	47.65
	Number of children	Less than 6	65.72
		More than 6	34.28
	Place of cooking food	Verandah	40.15
		Multipurpose room	30.77
		Open space	27.39
		Separate Kitchen	1.69
	Ventilation in kitchen	Proper	22.26
		Improper	77.74
	Cooking fuel/stove used	Traditional	96.62
		Modern	3.38
	Source of energy	Purchased	60.79
		Collected	20.26
		Animal dung	18.95

Source: Based on field survey, 2009-10

(27 per cent). Only a small percentage (2 per cent) reported of having a separate kitchen for cooking food. They were short of living space, so instead of consuming space for a separate kitchen they used the space in the living room used as sleeping for cooking food, which increases exposure time. More than three fourth (78 per cent) reported of improper ventilation in cooking area. Field surveys revealed that most of the lower income households (97 per cent) used traditional fuels (fuel wood, dung, crop residues, coal, kerosene) and traditional stoves (*chulhas*) or open flames for cooking food either in a multipurpose room without ventilation or in the *veranda*. Among the respondents using modern fuels (3 per cent) most of them reported of using electric heaters with illegal connections i.e. they were not paying the electricity bills, or they were using LPG without pass books, buying it privately according to their needs. More than half of the sample (63 per cent) reported of spending <5 hours per day for kitchen work while rest (37 per cent) reported of spending more than 5 hours for kitchen work. Longer duration of kitchen work is mainly due to inefficiency of traditional cooking fuels/stoves used. Their lies a wide range of differences in types of cooking fuel used in urban areas. These fuels are made available from different sources depending on the convenience, availability, preference and economic conditions of households. Table 1 shows that of the total low income households, 61 per cent reported that they were purchasing the cooking fuel and 19 percent reported that since they kept cows/buffaloes at home for milk, the cow

dung was freely available, while 20 per cent reported of collecting the cooking fuels (twigs, dry leaves/plants etc.). This process also required 3 to 4 hours time per day. Collecting fuel and carrying it either on the back or on the shoulder incepts backache, shoulder ache, tiredness etc.

Identified risk factors associated with indoor air pollution

Risk factors associated to indoor air pollution are unwanted consequences which are related to some activity and plays catalysing role by its probability. Women being responsible for cooking food are regularly exposed to high levels of pollutants emitted from cooking fuels during cooking. Low income women carry double burden as in most societies it becomes the responsibility of women not only to cook food but also to collect the biomass fuel which needs at least 2 to 4 hours per day for its collection. Thus, women are vulnerable to backache, shoulder ache and headache problems from carrying heavy loads. Although majority of people who are at risks are the dwellers of the rural areas of the world's poorest countries but still this is becoming interestingly a problematic situation for poor urban dwellers, this trend is likely to increase with the urban transition . The exposure level mainly depends upon the choice of fuels/stoves, time spent for cooking, and intensity of exposure to fire/ smoke, ventilation facility, etc. All this proceeds towards hazardous consequences for women's health and undermines their life expectancy. The long term consequences to women's life of adaptation to stressful environmental condition may deteriorate with physical and mental well-being which in turn may cause greater damage to the environment. (Rishi, 2001).

Household surveys revealed that indoor air quality is affected by a variety of factors. Air can convey animate material that is damaging to health, for example mould can provoke health problems, crowding can increase the concentration of air borne pathogens, excessive humidity can facilitate the spread of infections etc. Indoor pollutant levels depend on factors such as cooking fuel used and the level of ventilation. Factors which contribute most to poor health are overcrowded, cramped living conditions which increase transmission of air borne infections. On the basis of household surveys the following risk factors were identified which play catalysing role in increasing indoor air pollution and its adverse effects (table 2 and figure. 2);House type (*kutcha/* semi-*pucca*);Indoor crowding (less than 20 sq. ft. sleeping place); Cooking in a multipurpose room; Use of biomass fuels/traditional stoves and *chulhas;*Absence of proper ventilation; Duration of kitchen work (more than 5 hours per day); Exposure to smoke (more than1 hour per day); Exposure to fire (more than 2 hours per day);

A perusal of table 2 shows the exposures to identified risk factors associated with indoor air pollution. All the low income households reported of indoor crowding due to large family size and less number of living room. Nearly all of them reported of exposure to heat for more than 2 hours per day and to smoke for more than 1 hour per day, as most of them (97 per cent) use biomass fuels/traditional stoves for cooking purpose. When these biomass fuels are burnt in inefficient traditional stoves (*chulhas*) it emits lot of smoke and heat. More than half of the households (65 per cent) reported of living in *kutcha*/semi-*pucca* houses which absorbs the emitted pollutants from the combustion of biomass fuels for longer duration. About 45 percent of households reported of improper ventilation in their houses, 36 per cent women reported of more than 5 hours per day kitchen work and 31 per cent reported of cooking in a multipurpose room.

Occurrence of diseases associated with indoor air pollution related risk factors in the low income households

Indoor air pollution is the most direct physical health risk. While the precise mechanism of how exposure causes disease is still unclear, it is known that small particles and several of other pollutants contained in indoor smoke cause inflammation of airways and lungs and impairs the immune response. Carbon monoxide also results in systematic effects by reducing the oxygen carrying capacity of the blood. Indoor air pollution leads to various short term and long term problems and specific diseases including respiratory infections, adverse pregnancy outcomes, eye related problems, cancers etc. Indoor air pollution contributes to acute respiratory infection in young children, chronic lung diseases and cancer in adults and adverse pregnancy outcomes (such as still births) in women exposed during pregnancy (Park, 2007). There is emerging evidence that indoor air pollution increases the risk of other health problems including low birth weight, prenatal mortality, asthma, otitis media, tuberculosis, nasopharyngeal cancer, cataracts, blindness and cardiovascular diseases. Women exposed to indoor smoke are three times as likely to suffer from pulmonary diseases (COPD), such as chronic bronchitis, than women who cook and heat with electricity, gas and other cleaner fuels (WHO, 2005).

Recent studies have revealed association between indoor air pollution and acute respiratory infections (Ezzati and Kammen, 2001a, 2001b). The short term health effects reported due to carbon-monoxide emission from cooking fuel are dizziness, headache, nausea, weakness etc. and in extreme case the inhaled carbon-monoxide gets blended with hemoglobin (Hb) to produce

Table 2: Indoor air pollution related risk factors and occurrence of associated diseases (in percentages) in the low income Households

Indoor air pollution related risk factors	Percentage of households affected	Occurrence of associated diseases	Percentage of households affected
1. House type (*kutcha*/semi-*pucca*)	64.73	1. Acute upper respiratory infection	70.84
2. Indoor crowding (less than 20 sq .ft. sleeping place)	100.00	2. Acute lower respiratory infection	48.29
3. Cooking in a multipurpose room	30.77	3. Low birth weight	47.15
4. Use of biomass fuels/traditional stoves	96.62	4. Chronic obstructive pulmonary diseases	46.70
5. Absence of proper ventilation	45.22	5. Pre natal mortality	15.49
6. Duration of kitchen work (more than 5 hours per day)	36.20	6. Eye irritation and cataract	14.12
7. Exposure to smoke (more than1 hour per day)	97.93	7. Asthma	12.98
8. Exposure to heat (more than 2 hours per day)	100.00	8. Pulmonary tuberculosis	10.93

Source: Based on field survey, 2009-10

carboxyhemoglobin (COHb) which reduces oxygen delivery to key organs and the developing foetus among pregnant women causing low birth weight and increases the risk of perinatal death. Similarly the polycyclic aromatic hydrocarbons (PAHs) constitute a large class of compounds released during the incomplete combustion or pyrolysis of organic matter (International Programme on Chemical Safety, 1998). These PAHs are activated by hepatic microsomal enzyme system to carcinogenic forms that bind covalently to DNA (Schwarz, et al., 1998).

The World Health Organization has assessed indoor air pollution as the 8th most important risk factor to the burden of diseases. High exposure to pollutants released during burning of bio-fuels in traditional *chulhas*/ovens for cooking(particulates, carbon monoxides and a range of organic compounds including formaldehyde, benzene and benzopyrene etc.) have been associated with serious health problems and as women are involved in cooking, they are the sufferers because they spend long hours before fire and smoke (Singh, 2004).

A perusal of table 2 and figure. 2 shows the distribution of sampled women respondents according to the occurrence of diseases due to indoor air pollutant exposure. Of the total sample, 71 per cent reported of acute upper respiratory infection (AURI), 48 per cent of acute lower respiratory infection (ALRI), 47 per cent of chronic obstructive pulmonary diseases (COPD), 47 per cent of low birth weight, 15 per cent of perinatal mortality, 14 per cent of eye irritation and cataract, 13 per cent of asthma, 11 per cent of pulmonary tuberculosis.

CONCLUSION

Foregoing analysis reveals that the sampled lower income households were found to be at a greater risk because they can't afford good quality housing and other infrastructure facilities, living in *kutcha*/semi-*pucca* having sub standard houses occupying only 1 room, mostly they were uneducated, having large families, using traditional fuels/stoves, cooking in *veranda*/multipurpose room/open air, having improper ventilation, most of them were exposed to smoke and high temperatures for long hours. These lower income women respondents were exposed to all the risk factors associated with indoor air pollution in higher degree and were the most vulnerable group suffering from various reported specific diseases like ALRI, AURI, COPD, asthma, pulmonary tuberculosis, perinatal mortality, low birth weight and eye irritation and cataract. The suffering is mainly due to the use of traditional fuels/stoves which emits high level of pollutants which in addition with poor housing and ventilation leads to poor health. These traditional fuels/stoves due to its inefficiency lead to long hour exposure to smoke/heat/high temperature which in turn leads to deteriorating health.

Indoor air pollution is a multi-dimensional problem. The above discussion exhibits that the low income households are the main sufferers of indoor air pollution and are most prone to its health effects. In future, traditional fuels will continue to be used by a large number of low income households because of the

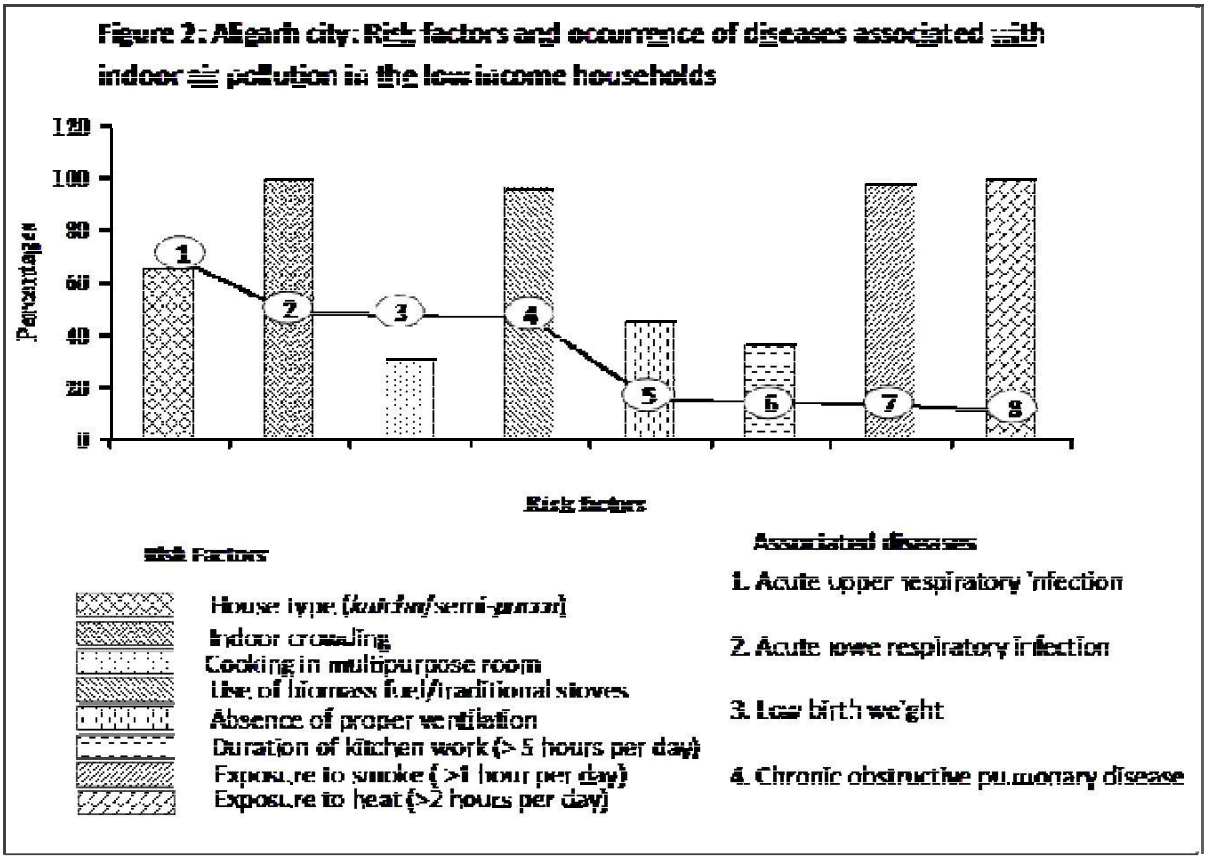

Figure 2: Aligarh City: Risk factors and occurrence of diseases associated with indoor air pollution in low income household Source: Based on field survey, 2009-10

economic backwardness and their unawareness towards indoor air pollution. It may be said that the burden of diseases due to IAP is highly concentrated to poor women and children in urban households. Viewing all these factors certain remedial strategies can be suggested these are:

availability, accessibility and affordability of poor income households to modern fuels; awareness towards the ill effects of indoor air pollution; development of cheap and less polluting energy sources like biogas, solar heaters etc; Improvement in *chulha* design (use of chimney and vented stoves); facility of proper ventilation in cooking area.

The various government structured programmes to allocate improved stoves/*chulhas* and modern energy sources to low income section can solve the complex problems of indoor air pollution. The additional income to the poor will make them affordable to choose modern cooking fuel solving the complex problem of indoor air pollution in their households. Although various agencies including ministries of the states and central government, planning commission, research institutes, non governmental organisations (NGOs), multinational organizations and other donor agencies are involved in managing household energy, indoor air pollution and health issues in India still the emphasis should be given on low income strata by the government because it is the prominent problem of low income household and will also continue in future with their poverty.

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