Risk assessment for indoor air pollution from urban households in a sub-tropical climate

1*Abha Lakshmi Singh and 1Saleha Jamal
1Department of Geography, Aligarh Muslim University, Aligarh, 202002, Uttar Pradesh (India)

*Email corresponding author: abhalakshmisingh@yahoo.com

Abstract

In India indoor air pollution is an important cause of mortality and morbidity, especially among the poor and most vulnerable populations. It increases the risk of acute respiratory infections, adverse pregnancy outcomes, perinatal mortality, asthma, otitis media, tuberculosis, cataracts, blindness, tuberculosis etc., but the ill impact of indoor air pollution is directly and more pronounced to respiratory problems and diseases. This paper seeks to identify the risk factors associated to indoor air pollution and examine the linkages between respiratory disease symptoms (cough, phlegm, breathlessness, wheezing, blood in sputum etc.) and house type (kutchha/semi pucca houses), type of fuel used (biomass/LPG) and kitchen locations (indoor kitchen with partition, indoor kitchen without partition, multi-purpose room, open air) in different income households of Aligarh city. In this study 2,101 women respondents belonging to different income groups were interviewed with the help of well structured questionnaire. Data was collected regarding housing conditions, type of fuel used, place of cooking, type of exposure and occurrence of respiratory diseases. On the basis of collected information risk factors were identified and symptomatic linkages of respiratory diseases and house type, type of fuel used and kitchen locations were established. Analysis has shown that symptomatic cases of respiratory diseases were significantly higher among those living in kutchha/semi-pucca houses, using biomass fuels and cooking in a multi-purpose room.

Keywords: Biomass; Exposure; Health; Respiratory; Women

1 Introduction

Risk is the potential that is a chosen action or com-motion which leads to a loss (an undesirable outcome). According to ISO risk is the ‘effect of uncertainty on objectives’. In this definition, uncertainties include events (which may or not happen) and uncertainties caused by ambiguity or a lack of information (ISO 31000, 2009). Risk assessment is a science based on systematic approach for evaluating the risk associated with an agent, a planned action or an existing condition. Risk assessment has also been described as a way of examining risks so that they can be better avoided, reduced or otherwise managed (Wilson and Crouch, 1987). Risk factor is a function determined by three variables, the likelihood of a particular hazard causing harm to the exposed individuals, the magnitude (severity) of the harms or their consequences, and the number of people exposed to the hazard (Cox and Tait, 1991). The World Health Organization has assessed the contribution of a range of risk factors to the burden of diseases and revealed that indoor air pollution is the 8th most important risk factor responsible for 2.7 per cent of the global burden of disease. Globally indoor air pollution is responsible for 1.6 million deaths due to pneumonia, chronic respiratory disease and lung cancer with the overall disease burden (in Disability-Adjusted Life Years or DALYs, a measure combining years of life lost due to disability and death) exceeding the burden from outdoor air pollution five fold. In high mortality developing countries, indoor smoke is responsible for an estimated 3.7 per cent of the overall disease burden (WHO, 2005). It has also been estimated that exposure to indoor air pollution may be responsible for nearly 2 million deaths in developing countries and for some 4 per cent of the global burden of diseases (Bruce et al., 2000). Evidence exists of association between low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer and cataract (Smith, 1987). Among the major contributors of indoor air pollution is burning of biomass fuels. Approximately half of the world’s population and 95 per cent in developing countries and more than 90 per cent in India still rely on unprocessed biomass fuels in the form of wood, dung and crop residues (Smith, 1990). There exist a direct relationship between the type of fuel and stoves used for cooking like LPG uses gas stoves, kerosene uses kerosene stoves while the biomass fuels are burnt in chulhas (traditional stoves made of three stones and plastered with mud). Of these, the chulhas are most inefficient in which the fuels are not completely burned. Nearly three fourth of the Indian households (including 3 out of 10 urban households and 8 out of 10 rural households) use open fires or chulhas without chimneys and appropriate ventilation. The unprocessed solid fuels typically releases 50 times more noxious pollutants like particulate matter, carbon monoxide, nitrogen dioxide, sulphur dioxide, formaldehyde and carcinogens such as benzo (a) pyrene and benzene (Ezzati et al, 2000). Women being responsible for cooking food, spend between 3 to 7 hours per day near the stove for cooking food are regularly exposed to high levels of pollutants emitted from cooking fuels during cooking (Singh, 2010). It is estimated that about half a million women and children die every year from indoor air pollution in India.
(WHO, 2005). In India indoor air pollution is an important cause of morbidity and mortality especially among the poorest and most vulnerable populations. Indoor air pollution mostly affects health through inhalation, but can also affect the eyes through contact with smoke. It is the cause for 1.6 million deaths in the world. India has among the largest burden of diseases due to use of biomass fuels and 28 per cent of deaths due to indoor air pollution in developing countries (Smith, 2000). 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. High concentration of indoor air pollution increases the risk of acute respiratory infections (ARI) in young children; chronic lung diseases and cancer in adults and adverse pregnancy outcomes (such as still births) in women exposed during pregnancy. It increases the risk of other health problems including low birth weight, prenatal mortality, asthma, otitis media, tuberculosis, nasopharyngeal cancer, cataracts, blindness and cardiovascular diseases (WHO, 2005). But the ill impact of indoor air pollution is directly and more pronounced to respiratory problems and diseases. 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 identify the risk factors associated to indoor air pollution and examine the linkages between respiratory diseases and house type, type of fuel used and kitchen locations in different income households of Aligarh city.

2 Materials and methods

This is a case study in which 2,101 women respondents belonging to different income groups (300 were from the high income group (> Rs. 25,000 per month), 620 from medium income group (Rs. 15,001-25,000 per month), 647 from low income group (Rs. 5,001-15,000 per month) and 533 from very low income group (< Rs. 5000 per month) were interviewed with the help of a well structured questionnaire. The questionnaire which was used required information regarding housing conditions, type of fuel used, place of cooking, type of exposures and occurrence of respiratory diseases. The sample was selected from the 14 wards of the Aligarh city (fig. 1). About 10 per cent households belonging to different income categories were sampled from the 14 wards of the Aligarh city. About 10 per cent households belonging to different income categories were sampled from the 14 wards of the Aligarh city. About 10 per cent households belonging to different income categories were sampled from the 14 wards of the Aligarh city.

Survey of 2010 households revealed that indoor air quality was 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 is overcrowded, cramped living conditions which increases transmission of air borne infections. On the basis of household surveys the risk factors were identified which play catalysing role in increasing indoor air pollution and its adverse effects (table 1 and fig 2),

3 Results and discussion

3.1 Identification of risk factors

The condition of most housing can be seen as highly questionable in terms of environmental quality. Field surveys revealed that the sampled households were found to be living in three types of houses; pucca houses (67 per cent), kutchha houses (11 per cent) and semi-pucca houses (22 per cent). The walls and roof of the pucca houses were made of bricks, cement and concrete; while the walls and roof of kutchha houses were made of bricks, mud, bamboo, thatched, tin sheets, polythene etc. The semi-pucca houses were made of a combination of both pucca and kutchha houses. One room was pucca while the verandah or the cooking place and toilet were kutchha. It was observed that in most of the semi-pucca houses the place of cooking was the most neglected part, either it was kutchha or semi-pucca having thatched tin roof. These built materials (used in kutchha/semi-pucca houses) absorbs the indoor gaseous (CO, CO₂, SO₂, NO, NO₃) and solid pollutants (Particulate matter-PM₁₀ and PM₂.₅) were collected from previous studies (Jamal, 2012).
smoke and other pollutants emitted from cooking fuels for longer period increasing the exposure duration of the individuals living in these houses, thus, posing severe health risks for e.g., sore throat, dry cough, phlegm and running nose all being symptoms of respiratory diseases. These sub-standard dwellings (kutcha, semi-pucca) were characterized by dampness and leaky roofs. Thus, the quality of the dwelling poses a great risk to the health of the dwellers. This has been identified as a risk factor associated with indoor air pollution. The survey revealed that of the total sample, nearly one third (33 per cent) reported of living in kutcha/semi-pucca house. Income-wise distribution shows that 65 per cent of the very low, 44 per cent of the low and 10 per cent of the medium income households were living in kutcha/semi-pucca houses. It was the low income poor households who lived in sub standard dwellings and complained of damp conditions and leaking roof. While none of the wealthy households reported of such problems.

3.1.2 Use of biomass fuels/ traditional stoves and chulhas

Cooking fuels are the most significant source of indoor air pollution. Most of the households use only one fuel but at times use a combination of fuel types were used. Survey results have shown that 51 per cent of households in Aligarh city cook their food on biomass fuels which was burnt in open fires or in chulhas or in simple stoves that release most of the smoke and at least 50 times more noxious pollutants than gas inside the homes. The resulting indoor air pollution is a major threat to health, particularly for women and young children who spend many hours close to the fire. Biomass smoke emits many health damaging pollutants (including particulate matter, carbon dioxide, carbon monoxide, sulphur dioxide, oxides of nitrogen, polycyclic aromatic hydrocarbons etc) and these pollutants cause considerable damage to the health particularly of women and children. During cooking with the biomass fuels on inefficient stoves, higher levels of pollutants are released and these are very harmful to health. There is evidence associating the use of biomass fuel with acute respiratory diseases, chronic obstructive lung diseases, adverse pregnancy outcomes etc. High degree of morbidity and mortality in India is due to indoor air pollution. Thus, this is an important risk factor which has been identified. The survey revealed that of the total sample, half (51 per cent) of them reported of using biomass fuels and traditional stoves for cooking purpose. Income-wise distribution shows that most of the lower income (97 per cent of very low and 79 per cent of low) and 6 per cent of medium income households were using biomass fuels and traditional stoves for cooking purpose. The figures indicate that it is the poorer households which face severe indoor air problems and its consequences.

3.1.3 Cooking in a multi-purpose room

Cooking locations were diverse. Field surveys revealed that women were found cooking in different places like in a indoor separate kitchen, indoor kitchen with partition, indoor kitchen without partition and in open air. Every other cooking locations from cooking in a multi-purpose room to cooking in verandah and in open air were more frequently used by the poor households. Thus, cooking space inside the living room or in a multi-purpose room not only pollutes the cooking environment but also the living environment gets polluted. Cooking in a multi-purpose room increases the time of exposure to toxic pollutants emitted from cooking fuels which has adverse effects and consequences on health; as the pollutants get trapped within the room where the individuals spend most of the time after the cooking period also. Number of pollutants from cooking fuels gets concentrated within the multi-purpose room which is also the living room and is detrimental to health because the polluted air is inhaled for a longer duration after cooking. During cooking with traditional fuels and stoves in a multi-purpose room due to incomplete combustion it releases extremely high and poisonous air pollutants and as the room is used for various purposes like living, sleeping etc. the exposure to these gases is very high. Due to cooking in a multi-purpose room which is also the living room, all other family members also get exposed to air pollutants. Thus, cooking in a multi-purpose room was identified as an as an important risk factor. Of the total sample, nearly 14 per cent reported of cooking in a multi-purpose room, of which, 31 per cent were from the very low, 19 per cent from the low and 2 per cent from the medium income households. Cooking locations bear a close relation to wealth. As wealth increases a shift towards indoor locations (separate kitchen) and use of better fuels was observed. These figures indicate that the economic status plays a vital role in deciding the place of cooking and as a result much of the adverse effects can be seen in the poorest section who are more exposed to high levels of indoor air pollution.

3.1.4 Absence of proper ventilation

We have already observed that most (97 per cent of very low, 79 per cent of low) of the lower income households burn biomass fuels in open fire places consisting of such simple arrangements as three rocks, u shaped hole in a block of clay (chulhas), a pit in the ground or in poorly functioning metal stoves (Smith, 1987). Combustion is incomplete in most of these inefficient stoves, resulting in substantial emissions which in the presence of poor ventilation produce very high levels of indoor air pollution (Air Quality Guidelines for Europe, 2000). Presence of proper ventilation both in living area and in cooking place is the best recommended way to reduce indoor air pollution. Ventilation ensures that the air flows outside to inside and vice-versa. In ideal conditions it may be suggested to install exhausts and chimneys in cooking area to exhale the polluted air and to let in the fresh air from outside. In India nearly 70 per cent of rural households don’t have ventilation (Kounteya, 2007) while in urban areas exposure to indoor air pollution has increased due to variety of reasons, including the construction of more tightly sealed buildings,
3.1.5 Duration of kitchen work (>5 hours per day)

Health effects are not only determined by the level of pollution but also, and more importantly, by the time people spend indoors breathing the polluted air, i.e. the exposure level (Bruce et al, 2000). People in developing countries are commonly exposed to very high levels of pollution for 3-7 hours daily over many years (Engel et al, 1998). It may be noted that due to traditional involvement in cooking women’s exposure is very much higher as compared to men. Also the exposure level among the young ones (<4 years of age) is often high as they remain around with their mothers while they are involved in kitchen work and thus they also spend many hours breathing the gaseous and solid pollutants like particulate emitted from cooking fuels. Women during cooking food stay in close proximity to hazardous pollutants. Findings indicate that particulate concentrations in personal breathing area during cooking hour with biomass ranges between 322.86 µgm⁻³ for PM10, 188.77 µgm⁻³ for PM2.5 and for gaseous pollutants, CO-3.34 ppm, CO2-509.71 ppm, SO2-0.07 ppm, NO-0.10 ppm, NO2-0.03 ppm which is much higher than Centre Pollution Control Board standards (Jamal, S., 2012). Thus, time spent for kitchen work (>5 hours per day) has been also identified as a major risk factor associated with household energy used and indoor air pollution. Of the total sample, nearly 27 per cent reported of spending more than 5 hours per day for kitchen work. Of which, 36 per cent of the very low, 30 per cent of low, 23 per cent of the medium and 18 per cent of the high income women respondents reported of spending more than 5 hours per day for kitchen work. Spending long hours by the lower and medium income households is understood because mostly they use biomass fuels and traditional inefficient stoves or chulhas which is really time consuming. But in case of high income households this phenomenon can be explained by the fact that they prefer to serve fresh meals at times and cook more than three meals per day. The time spent for kitchen work may depend on various factors i.e. efficiency of cooking fuel/stove, amount of food to be cooked, size of family etc.

3.1.6 Exposure to smoke (>1 hour per day)

Cooking fires are almost certainly the main source of personal exposure to air pollutants especially for women in Aligarh city. Biomass fuel is the dominant cooking fuel especially among the lower income households and is likely to remain so far many years to come because of the rising prices of LPG (presently it is Rs. 400 per cylinder). Exposure monitoring undertaken for this study indicated that the biomass fuel users were the most exposed to particulates and gases followed by LPG (Jamal, S., 2012). Biomass smoke contains dozens of health damaging pollutants (Smith, 1987). Statistics say that the indoor smoke from solid fuels is the 4th leading high mortality risk factor in developing countries. Women spend 3-7 hours in kitchen everyday and breathe in smoke equivalent to consuming two packs of cigarettes (Down to Earth, July 15, 2007). According to WHO some 400,000 to 550,000 women and children below 5 years of age die prematurely each year in India because of this deadly smoke (Down to Earth, July 15, 2003). Thus, the deadly pollutant present in smoke when inhaled causes mounting health effects. Exposure of women to smoke (>1 hour per day) has been identified as a major risk factor associated with household energy used and indoor air pollution. Of the total sample, nearly 53 per cent reported that they were exposed to smoke for more than 1 hour per day. Of which, 98 per cent of very low, 82 per cent of the low, 10 per cent of the medium income women respondents reported that they were exposed to smoke for more than 1 hour per day. None of the high income women respondents reported of exposure to smoke for more than 1 hour because all of them were using modern cooking fuel/stoves and were having proper ventilation facility. The smoke from their homes went out very quickly. It is the poor women who had to face the exposure from smoke for long hours and they had to bear the consequences.

3.1.7 Exposure to heat (>2 hours per day)

Women while cooking food are not only exposed to noxious pollutants but are also exposed to fire/heat/high temperature, more with biomass fuel burnt as open fire. During winter, exposure to heat may increase due to warming process either with electricity or with biomass fuels which is the cause of various ill health effects. Exposure to heat for more than 2 hours per day has been identified as an important risk factor associated with household energy used and indoor air pollution. Of the total sample, nearly 78 per cent reported that they are exposed to heat (>2 hours per day) during cooking process. Of which, all the very low income respondents, 98 per cent of the low, 67 per cent of the medium and 48 per cent of the high income women respondents reported that they are exposed to heat for more than 2 hours per day during cooking.

3.1.8 Indoor crowding (<20 sq. ft. sleeping place)

Indoor crowding depends on both the number of people in the household and the way in which the residential space is managed. Crowding within the home
is equally important and is analysed as one of the risk factors associated with indoor air pollution. Excessive crowding clearly affects the well-being of a household, and many studies have indicated that it can also affect health (Bradley et al., 1991). Another characteristic common to most of the poorer homes is crowded, cramped conditions. It is possible, however, for crowding to result even in homes with several rooms, especially if the use of most rooms is restricted to one or two household members. This is because the overall number of rooms or the amount of floor space per person is insufficient to accommodate the number of residents. The survey revealed that of the total sample, more than half (68 per cent) reported of having less than 20 sq. ft. per person sleeping place. Income-wise distribution shows that all the very low and low, 55 per cent of medium and 15 per cent of the high income households were having less than 20 sq. ft. per person sleeping. Although the high-income households have many rooms but 15 per cent of the respondents reported of using only 1 or 2 rooms for sleeping.

3.2 Linkages of respiratory disease symptoms and house type, fuel used and kitchen locations

The sampled respondents reported of occurrence of various diseases associated with indoor air pollution like of acute respiratory infection (AURI and ALRI), chronic obstructive pulmonary diseases (COPD), low birth weight, obstructive pulmonary diseases, asthma, pulmonary tuberculosis, cancer, pre-natal mortality, anaemia, pneumonia, eye irritation, cataract, prenatal mortality, asthma, prematurity, eye irritation, cataract, congenital anomalies, etc. The most common and frequently reported were respiratory problems and diseases. Table 2 shows that about 85 per cent of the very low income, 79 per cent of the low, 50 per cent of the medium and 40 per cent of the high income women respondents reported of having respiratory problems and diseases. Table 1 shows that about 85 per cent of the very low income, 79 per cent of the low, 50 per cent of the medium and 40 per cent of the high income respondents reported of having less than 20 sq. ft. per person sleeping place. Income-wise distribution shows that all the very low, 55 per cent of medium and 15 per cent of the high income households were having less than 20 sq. ft. per person sleeping place. Although the high-income households have many rooms but 15 per cent of the respondents reported of using only 1 or 2 rooms for sleeping.

Table 1: Income-wise distribution of the sampled women respondents/households (in percentages) according to the identified risks factors associated with indoor air pollution

<table>
<thead>
<tr>
<th>Income group</th>
<th>Number of sampled WR/HH (semi-pucca/kutcha)</th>
<th>House type Use of biomass fuel/ multi-purpose chulhas</th>
<th>Cooking in a room</th>
<th>Absence of proper ventilation</th>
<th>Duration of kitchen work (&gt;1 hour per day)</th>
<th>Exposure to smoke (per day)</th>
<th>Exposure to heat (&gt;2 hours per day)</th>
<th>Indoor crowding</th>
<th>Exposure to number of risk factors</th>
<th>Average exposure to risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>301</td>
<td>9.84</td>
<td>6.45</td>
<td>1.45</td>
<td>17.58</td>
<td>48.38</td>
<td>14.68</td>
<td>3</td>
<td>43.94</td>
<td>18.11</td>
</tr>
<tr>
<td>Medium</td>
<td>620</td>
<td>43.89</td>
<td>79.44</td>
<td>18.7</td>
<td>29.52</td>
<td>9.84</td>
<td>67.42</td>
<td>55.32</td>
<td>8</td>
<td>22.12</td>
</tr>
<tr>
<td>Low</td>
<td>647</td>
<td>43.89</td>
<td>79.44</td>
<td>18.7</td>
<td>29.52</td>
<td>9.84</td>
<td>67.42</td>
<td>55.32</td>
<td>8</td>
<td>22.12</td>
</tr>
<tr>
<td>Very low</td>
<td>533</td>
<td>64.73</td>
<td>96.62</td>
<td>30.77</td>
<td>45.22</td>
<td>97.93</td>
<td>100</td>
<td>100</td>
<td>8</td>
<td>61.83</td>
</tr>
<tr>
<td>Total</td>
<td>2,101</td>
<td>32.83</td>
<td>50.88</td>
<td>13.99</td>
<td>25.94</td>
<td>53.02</td>
<td>78.49</td>
<td>67.52</td>
<td>8</td>
<td>43.54</td>
</tr>
</tbody>
</table>

WR: Women respondents, HH: Household

Source: Based on field survey, 2010-11
of modern fuels for cooking purposes, use of neat, hygienic separate well-ventilated kitchen increases and the time involved in cooking decreases. As the income increases the exposure of women to smoke, heat and fire decreases, so the higher income households do not suffer as much from the respiratory diseases as the lower income.

In this part an attempt has been made to establish the linkages between respiratory diseases symptoms with house type, type of fuel used, cooking locations with the help of self-reported symptoms of respiratory diseases. The linkages between self-reported respiratory disease symptoms includes cough, phlegm, breathlessness, wheezing, blood in sputum and any other symptoms like fever, sore throat, running nose etc. On the basis of self-reported symptoms the occurrence of respiratory diseases were examined in different house types (kutcha/semi-pucca, pucca), in the households using different types of fuels (biomass, LPG) and cooking in different locations (indoor kitchen with partition, indoor kitchen without partition (veranda), multi-purpose room, open air) (tables 3(i), (ii), (iii)). Analysis on the basis of self-reported symptomatic cases of respiratory diseases and type of house has shown that it was significantly higher among those living in kutcha/semi-pucca houses (7 per cent reported of any other respiratory symptoms, 5 per cent of cough, 5 per cent of breathlessness, 4 per cent of wheezing, 4 per cent of phlegm and 2 per cent of blood in sputum) as compared to those living in pucca houses (5 per cent reported of any other respiratory symptoms, 2 per cent of cough, 2 per cent of wheezing, 2 per cent of phlegm, 2 per cent of breathlessness and 0.42 per cent of blood in sputum). This was due to the fact that the kutcha material absorbs the emissions from cooking fuels causing longer period of exposure and many times the house remains damp posing health hazards. This was also due to poor ventilation and lower ceiling height in kutcha houses as compared to pucca houses. Moreover, the use of LPG, is higher among the residents (usually the higher income class) of pucca houses. The results have been presented in table 3(i). In case of households using biomass fuels (1,069) and those using LPG (899), the symptomatic cases have been found significantly higher among those using biomass fuels (18 per cent reported of any other respiratory symptoms, 15 per cent of cough, 12 per cent of wheezing, 12 per cent of breathlessness, 9 per cent of phlegm, 6 per cent of blood in sputum) as compared to those using LPG (10 per cent reported of any other respiratory symptoms, 4 per cent of wheezing, 4 per cent of cough, 4 per cent of breathlessness, 3 per cent of phlegm and 2 per cent of blood in sputum). It has been already discussed in previous chapters that the biomass emits many toxic pollutants which poses greater health risks. The results have been presented in table 3(ii). Similar analysis on the basis of self-reported symptomatic cases of respiratory diseases and kitchen locations (indoor kitchen with partition, indoor kitchen without partition (veranda), multi-purpose room, open air) was also found to be significantly higher among those cooking in multi-purpose room (11 per cent reported of any other respiratory symptoms, 6 per cent of wheezing, 6 per cent of breathlessness, 5 per cent of cough, 5 per cent of phlegm and 2 per cent of blood in sputum), indoor kitchen with partition (8 per cent reported of any other respiratory symptoms, 5 per cent of cough, 5 per cent of wheezing, 4 per cent of phlegm, 4 per cent of breathlessness and 1 per cent of blood in sputum) as compared those who cook in indoor kitchen without partition (6 per cent reported of any other respiratory symptoms, 3 per cent of wheezing, 3 per cent of breathlessness, 3 per cent of cough, 2 per cent of phlegm and 0.77 per cent of blood in sputum) and in open air (4 per cent reported of any other respiratory symptoms, 3 per cent of wheezing, 2 per cent of breathlessness, 1 per cent of cough, phlegm and 0.67 per cent of blood in sputum). This is due to higher exposure to smoke in case of indoor cooking as compared to that of open air cooking. These results have been presented in table 3(iii). These results of linkages between respiratory disease symptoms and the type of fuel used (i.e., biomass and LPG), type of house (kutcha/semi-pucca) and location of the kitchen reveals that the three variables have significant health impacts as far as respiratory disease symptoms are concerned. Prevalence of respiratory disease symptoms are significantly higher for those who use biomass fuels, cook indoor in a multi-purpose room and live in kutcha/semi pucca houses.

4 Conclusion

Since indoor air pollution with the greatest health consequences remains unseen so it is important to identify the risk factors which will help in avoiding, reducing and managing its bad effects. In the foregoing
Table 3: Linkages of respiratory disease symptoms and house type, fuel used and kitchen location (in percentages) in the sampled households

<table>
<thead>
<tr>
<th>Respiratory disease symptoms</th>
<th>No. of households</th>
<th>Cough</th>
<th>Phlegm</th>
<th>Breathlessness</th>
<th>Wheezing</th>
<th>Blood in sputum</th>
<th>Any other respiratory symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) House type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kutcha/semi-</td>
<td>690</td>
<td>5.07</td>
<td>4.05</td>
<td>4.78</td>
<td>4.49</td>
<td>1.73</td>
<td>6.96</td>
</tr>
<tr>
<td>Pucca</td>
<td>1411</td>
<td>2.35</td>
<td>1.98</td>
<td>1.63</td>
<td>2.05</td>
<td>0.42</td>
<td>4.6</td>
</tr>
<tr>
<td>(ii) Fuel type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>1069</td>
<td>14.59</td>
<td>9.45</td>
<td>11.6</td>
<td>12.25</td>
<td>5.52</td>
<td>18.15</td>
</tr>
<tr>
<td>LPG</td>
<td>899</td>
<td>4.23</td>
<td>3.23</td>
<td>4</td>
<td>4.34</td>
<td>1.67</td>
<td>9.69</td>
</tr>
<tr>
<td>(iii) Kitchen locations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoor kitchen with partition</td>
<td>992</td>
<td>4.94</td>
<td>4.44</td>
<td>4.03</td>
<td>4.74</td>
<td>1.2</td>
<td>7.56</td>
</tr>
<tr>
<td>Indoor kitchen without partition (verandah)</td>
<td>520</td>
<td>2.88</td>
<td>2.31</td>
<td>3.07</td>
<td>3.46</td>
<td>0.77</td>
<td>5.77</td>
</tr>
<tr>
<td>Multipurpose room</td>
<td>294</td>
<td>5.1</td>
<td>4.76</td>
<td>5.78</td>
<td>6.46</td>
<td>2.04</td>
<td>10.88</td>
</tr>
<tr>
<td>Open air kitchen</td>
<td>295</td>
<td>2.03</td>
<td>1.35</td>
<td>2.37</td>
<td>2.71</td>
<td>0.67</td>
<td>4.41</td>
</tr>
</tbody>
</table>

Source: Based on field survey 2010-11

Analysis the researchers have identified the eight important risk factors associated with indoor air pollution. These are living in kutcha/semi pucca houses, using biomass fuels/traditional stoves and chulhas, cooking in a multi-purpose room, absence of proper ventilation, spending long hours in kitchen, exposure to smoke and heat and indoor crowding. These conditions aggravate indoor air pollution causing morbidity and mortality especially among the poor and most vulnerable (women and children) population. Further, to prove that these risk factors accentuate indoor air pollution linkages between respiratory diseases and use of different types of fuels (biomass fuels and LPG), house type (kutcha/semi pucca) and kitchen locations (indoor kitchen with partition, indoor kitchen without partition, multi-purpose room, open air) was established on the basis of symptoms of respiratory diseases (cough, phlegm, breathlessness, wheezing, blood in sputum etc.). It was also observed that the prevalence of respiratory symptoms was significantly higher among those cooking on biomass fuel/traditional stoves, living in kutcha/semi pucca houses and cooking in a multi-purpose room.

In consideration with above factors, certain suitable strategies for reducing and managing the bad effects of indoor air pollution have been suggested as follows:
(i) improving cooking devices (fuels, stoves),
(ii) improving living environment (proper housing, ventilation through doors and windows, separate kitchen) and
(iii) behavioural changes (spending less time in kitchen before the stove, fuel drying, using pot lids, proper maintenance of stoves and keeping children away from smoke).

References
Kountiya, S. "Indoor Air Pollution is the Biggest Killer", Times of India, (2007, 22 March).