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Health Impact of Indoor Air Pollution

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ABSTRACT

Background: The domestic smoke exposure increases the risk of a range of common and serious diseases. Further, association of exposure with chronic bronchitis and chronic obstructive lung disease is quite well established in recent researches. This work was carried out to determine the health impact of indoor air pollution in rural hill region of Nepal.

Methods: A cross-sectional study on health impact of indoor air pollution to exposed kitchen dwellers and children, was done using random sampling method devised with probability proportion in Malikarjun Village Development Committee, Nepal. This study was conducted in two phases, in first phase. Adult kitchen dwellers were assessed for prevalence of respiratory disorder while in second phase, during three months Acute Respiratory Infection episodes of children below two years were recorded.

Results: Eight kinds of respiratory ailments and related symptoms were prevalent in adult respondents of 42 households. Cough phlegm, breathlessness, wheezing, chronic obstructive pulmonary disease, and bronchial asthma were significantly varied with higher exposure category ($P<0.05$) and smoking habit ($P<0.01$). Peak expiratory flow rate PEFR results significantly varied with both smoking habit and exposure level both in male and female ($P<0.01$). Correlation analysis denoted higher prevalence of diseases and symptoms in smokers ($r = 0.464$; $P<0.01$). Acute Respiratory Infection episodes per child was significant in grade I ($P<0.01$) and grade II ($P<0.05$) for both exposure level and parental smoking habit.

Conclusions: A significant association between exposure of Indoor Air Pollution and prevalence of respiratory disorders and related symptoms in kitchen dwelling adults and children was found.

Key words: acute respiratory infection, exposure duration, indoor air pollution, prevalence, respiratory disorder.

INTRODUCTION

The biomass smoke exposure increases the risk of a range of common and serious diseases of both children and adults.[1] In Nepal, acute respiratory infection (ARI), tuberculosis and other chronic obstructive pulmonary diseases (COPD), continue to prevail at high rates, largely because of lack of access to higher qualities of energies for its 75% population living in rural areas. As the rural Nepalese are crippled of harsh climate, insouciant health policies and minimal researches, the effects of such indoor air pollution have multiplied.

The role of indoor exposure to biomass fuels in the development of the disease has been examined in various studies. As the severity of health effects are better determined through the time people spend breathing polluted air, this study takes into consideration, the

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exposure duration of the people in the smoke. This work was carried out to determine the health impact of indoor air pollution in rural hill region of Nepal.

METHODS

A cross-sectional study was carried out among adults and children to investigate the risk factors for the development of respiratory disorders to kitchen dwellers in Malikarjun Village Development Committee (VDC) of far-western mountain region, Nepal from March 14 - April 14, 2008. Ethical approval was taken from Nepal Health Research Council. The study area consists of poor, rural and ethnically homogenous (> 90% *Chhetri*). The houses in village represent typical mountain scattered settlements and are made entirely of mud-stone. There is no access of electricity and only some of households have solar panels installed, while the majority of households depend on kerosene and pine lamp (*Jhuro*). Fuel wood is the only source of energy for cooking which is extracted from locally available plant species comprising *Rhododendron spp.*, *Quercus spp.*, *Alnus nepalensis*, and *Pinus wallichiana*. The study area is free from Industrial and atmospheric pollution.

This study comprised two aspects; evaluation of respiratory health of adults in relation to indoor air pollution, and finding relationship between domestic smoke exposure to the Acute Respiratory Infection in children below two years of age. Prior to conduct any research instrument, consent of human subject's was obtained.

There were 422 households and 2249 population in the VDC, and total children below age of two were 171. Sixty-two households were selected applying standard statistical formula; the selection was devised with proportion to household distribution in all nine wards of VDC.

$$n = \frac{NZ^2P(1-P)}{Nd^2P+Z^2p(1-P)}$$

Where, n = sample size

N = total number of households

Z = confidence level (at 95 % level Z = 1.96)

P = estimated population proportion (0.05, this maximize the sample size)

d = error limit of 5 % (0.05)

In each selected households, physical examination of housing parameters were conducted, which included: Kitchen's location, partition and dimension; stove type, number of rooms, and number and dimension of windows, doors and ventilations. Further for the health survey, respondents were selected from the sample households. Respondent sample size was taken as 225 (10% of total population). This study included women, children and also men; men in the study area were identified equally vulnerable to domestic smoke pollution. Most of the married men cook at least once in a day for their special notion of having sacred meal (*Rhosyo khane*). Thus, total respondent sample size was split in three sub-groups, women (n= 107; 20% of the total population of women between 15-60 years of age), men (n= 47; 30% of total adult sample size) and children (n= 71; about 50% of the total population of children below two years of age). Moreover, criteria for selection of adult respondents were kitchen dwelling women having age between 15 to 60, and man who cooked at least once in a day. However, locals whose residing period in the VDC were less than six month and not involved in cooking were excluded from the survey. Similarly, eligible population for ARI episodes identification was children below two years of age who was permanently residing in the area. In older children, aged two to four years, estimates of exposure to smoke could not be made because the children were too mobile. For this reason, no attempt was made to collect data on smoke exposure in this age group. Further, respondents were categorized by as non-smoker as those who had never smoked or had smoked less than one cigarettes or equivalent a day for as long as a year and smoker as those who regularly smoked one or more cigarettes or equivalent a day.

We used the standardized British Medical Council questionnaire with some modifications, which included variables of potential etiological relevance such as demography, respiratory symptoms, smoking, housing and life style.[2,3] The questionnaire was applied to each selected adult by face-to-face interview. In addition, respiratory ailments of respondents identified in this study were in fact recorded through their hospital records, no effort was made to clinically test for the disease; and only the symptoms were compiled through questionnaires. Again, their health status was determined by using peak flow measurements (expiratory capacity of lungs) through a peak flow meter, which is a portable, inexpensive, hand-held device used to measure how air flows (Expiratory rate) from lungs in one "fast blast".

ARI information of children was recorded based on its severity, as classified by government of Nepal.[4] In order to record different episodes of ARI the following working definition was adopted: If a child suffering from ARI of any grade was reported to be completely free from signs and symptoms of ARI for at least 48 hours and contracted ARI again, then it was considered a new episode of ARI.

All selected children below two years were visited every two weeks by trained community health worker who were under the close supervision of the paramedical worker (Health Assistant). Exposure to domestic smoke was assessed by asking the mothers about the average amount of time per day spent near the fireplace by infants and children under two years of age.[5,6]

The questionnaires and the checklists were pretested in the field before the study commenced. Statistical analyses were made with the help of Statistical Package for Social Science (SPSS) version-12 using frequency tables, Analysis of Variance (F-statistic) and Correlation.

RESULTS

A survey of 62 sample households in the VDC revealed a total of 495 people with an average family size 7.98 per household and sex ratio (Male: Female) of 1.05:1. On average one family had one male smoker, while two families had one female smoker. The disease prevalence of sample respondents (154), most of whom were women (107) showed that total eight kinds of problems of respiration and related symptoms in 42 (67.74%) households. The major respiratory ailments that we recorded were COPD, bronchial asthma, ENT problem and eye problem, similarly other related symptoms were cough, phlegm, breathlessness and wheezing (Table 1).

Table 1. Overall frequency of disease/problem

S.N.	Diseases/Problem	Frequency (%)
1	Cough	46 (25.69)
2	ENT	35 (19.55)
3	Phlegm	27 (15.08)
4	Breathlessness	27 (15.08)
5	Wheezing	21 (11.73)
6	Eye Problem	10 (5.58)
7	Bronchial Asthma	10 (5.58)
8	COPD	3 (1.67)
Total		**179 (100)**

Exposure duration and smoking habit played crucial role in determining the health of respondents. There were 80 smokers, and 70 respondents who never took smoking habit, while 3 have quitted the habit because of their fragile health. The symptomatic respondent and disease prevalence was significantly higher in case of smokers ($P<0.01$) (Table 2). Similarly, diseases and symptoms prevalence namely: cough, phlegm, breathlessness, wheezing, COPD, and bronchial asthma were higher in higher exposed category of respondents ($P<0.05$) (Table 3).

Correlation analysis of prevalent ailments versus different household characteristics and behavioral factors showed mutual correlation trend. The number of cases of disease occurring in smokers was significant ($r= 0.464$; $P<0.01$). Similarly, the number of cases of disease were also increased with the increasing number of stories of house ($r = 0.102$), and also with fuel wood amount ($r = 0.037$), but decreased with increase of door size ($r = -0.131$) and kitchen area ($r= -0.108$); however the results were insignificant.

Peak flow meter analysis was carried on only 81 responded out of 154 due to reluctance of rest in using the meter. Peak expiratory flow rate (PEFR) measured by the peak flow meter was separately analyzed to the exposure duration and smoking habit of respondents (Table 4, 5). There were significant differences in PEFR results between the smokers and non-smokers both in men and women ($P<0.01$). Similarly, PEFR result also significantly varied according to the exposure duration of domestic smoke pollution both among men and women ($P<0.01$).

Among infants and children between 1 and 2 years, the episodes of ARI per child increased with the increased level of smoke exposure while parental smoking habit aggravated the cases (Table 6, 7). The increase is more pronounced in grade I, in both cases, rather than other two higher levels (grade II and grade III).

DISCUSSION

Indoor pollution from biomass fuels such as wood, dry dung, crop residues for cooking is still a problem in developing countries. Households reliant on biomass generally use the fuel indoors, in open fires or poorly functioning stoves, and usually with inadequate venting of smoke. The persons most frequently affected are females who do the cooking for households in rural villages. They suffer from impaired health due to prolonged and repeated contact with harmful pollutants.[7] Mortality and morbidity from obstructive lung disease has increased among these.[8] The role of indoor exposure to biomass fuels in the development of the disease has been examined in various studies. This study's results show agreement with the findings of the published study summarized by various authors.[6, 9-11]

Pandey, in one of the study in rural hill region of Nepal, investigated 1,375 subjects to determine whether there was any relation between domestic smoke pollution and chronic bronchitis. He found that the prevalence of chronic bronchitis in females increased with the duration of time per day spent near the fireplace. Further, his study showed a high prevalence of chronic bronchitis (12.57%) among nonsmoking females, strongly suggesting the association between IAP and prevalence of disease.[9] However, we observed the various respiratory diseases and allied symptoms associating both with exposure duration ($P<0.05$) and smoking habit ($P<0.01$).

Table 2. Prevalence of diseases based smoking habitat.

Disease/Problem	Smoking Habit		
	Never smoked	Current smoker	Previous smoker
EYE*	-	10 (8.26%)	-
ENT	17 (36.17%)	18 (14.87%)	-
Cough*	12 (25.53%)	32 (26.44%)	2 (18.18%)
Phlegm*	5 (10.63%)	20 (16.52%)	2 (18.18%)
Breathlessness*	5 (10.63%)	19 (15.70%)	3 (27.27%)
Wheezing*	5 (10.63%)	14 (11.57%)	2 (18.18%)
COPD*	-	2 (1.65%)	1 (9.09%)
Bronchial asthma*	3 (6.38%)	6 (4.95%)	1 (9.09%)
Total	**47 (100.00%)**	**121 (100.00%)**	**11 (100.00%)**

* P<0.01(F-Statistic)

Table 3. Prevalence of diseases based on exposure duration

Disease/Problem	Exposure Duration (hours)		
	<2	2 - <4	≥4
EYE	5 (3.25%)	4 (2.60%)	1 (0.65%)
ENT	18 (11.69%)	13 (8.44%)	4 (2.60%)
Cough*	8 (5.19%)	27 (17.53%)	11 (7.14%)
Phlegm*	1 (0.65%)	15 (9.74%)	11 (7.14%)
Breathlessness*	1 (0.65%)	15 (9.74%)	11 (7.14%)
Wheezing*	-	10 (6.49%)	11 (7.14%)
COPD*	-	2 (1.30%)	1 (0.65%)
Bronchial asthma*	-	5 (3.25%)	5 (3.25%)
Total			

*P<0.05 (F -Statistic)

Table 4. Peak flow rate of respondents as per the smoking habit

Smoking habit		Peak flow rate (liter/meter)*			Total
		<200	200-399	≥400	
Never smoked	Female	3 (18.75%)	23 (40.35%)	2 (25.00%)	28
	Male	1 (6.25%)	1 (1.75%)	5 (62.50%)	7
	Total	**4 (25.00%)**	**24 (42.11%)**	**7 (87.50%)**	**35**
Current smoker	Female	8 (50.00%)	24 (42.11%)	0 (0.00%)	32
	Male	2 (12.50%)	8 (14.04%)	1 (12.50%)	11
	Total	**10 (62.50%)**	**32 (56.14%)**	**1 (12.50%)**	**43**
Previous smoker	Female	2 (12.50%)	-	-	2
	Male	-	1 (1.75%)	-	1
	Total	**2 (12.50%)**	**1 (1.75%)**	**-**	**3**
Grand Total		**16**	**57**	**8**	**81**

*P<0.01 (F-Statistic)

Table 5. Peak flow rate of respondents as per the exposure duration

Exposure duration (hours)		Peak flow rate (liter/meter)*			Total
		<200	200-399	≥400	
<2	Female	-	30 (52.63%)	2 (25.00%)	32
	Male	-	5 (8.77%)	5 (62.50%)	10
	Total	**-**	**35 (61.40%)**	**7 (87.50%)**	**42**
2 - <4	Female	7 (43.75%)	15 (26.32%)	-	22
	Male	1 (6.25%)	5 (8.77%)	1 (12.50%)	7
	Total	**8 (50.00%)**	**20 (35.09%)**	**1 (12.50%)**	**29**
≥4	Female	6 (37.50%)	2 (3.51%)	-	8
	Male	2 (12.50%)	-	-	2
	Total	**8 (50.00%)**	**2 (3.51%)**	**-**	**10**
Total		**16**	**57**	**8**	**81**

*P<0.01(F -Statistic)

Table 6. ARI episodes according to the time spent in fireplace per day

Exposure time (hours/day)	No. of infants	0-1 years ARI episode by grade			No. of Children	1-2 years ARI episode by grade		
		I	II	III		I	II	III
< 2	14	17 (1.21)	2 (0.14)	-	12	7 (0.58)	-	-
2 - <4	12	18 (1.50)	2 (0.17)	-	16	16 (1.00)	2 (0.13)	1 (0.06)
≥ 4	17	19 (1.12)	3 (0.18)	-	7	13 (1.86)	2 (0.29)	1 (0.14)
Total	**43**	**54 (1.26)**	**7 (0.16)**	**-**	**35**	**36 (1.03)**	**4 (0.11)**	**2 (0.06)**

Note: Average episode per child in parentheses, P<0.01 for the ARI in grade I (both age group combined), P<0.05 for the ARI in grade II (both age group combined).

Table 7. ARI episodes according to the smoking habits of parents

Smoking Habit	No. of Infants	0-1 years ARI Episode by grade			No. of Children	1-2 years ARI Episode by grade		
		I	II	III		I	II	III
Smoker	23	37 (1.61)	6 (0.26)	-	19	29 (1.58)	4 (0.21)	2 (0.11)
Never smoked	13	17 (1.31)	1 (0.08)	-	16	7 (0.50)	-	-
Total	**36**	**54 (1.50)**	**7 (0.19)**	**-**	**35**	**36 (1.03)**	**4 (0.11)**	**2 (0.06)**

Note: Average episode per child in parentheses, P<0.01 for the ARI in grade I (both age group combined), P<0.05 for the ARI in grade II (both age group combined).

The study conducted in Van city of eastern Turkey outlined the prevalence of chronic Bronchitis-Asthma symptoms in biomass fuel exposed females; and result showed that longer duration (>20 years) of biomass fuel usage female prevailed higher asthma related symptoms (P value 0.0005), asthma disorder (P value 0.07), and bronchitis symptoms (P value 0.623) than lower (1-20 years) biomass fuel usage.[10] Though, our study has not considered the duration of using fuel types but daily exposure duration to biomass fuel, that is, exposure duration if consider analogous; results of our study show agreement with other study showing higher exposure duration having higher prevalence of respiratory disorder and related problems.

Moreover, there was significant increment in the prevalence of diseases and their symptoms with level of exposure and smoking habit; however, trend of diseases and their symptoms were not continuous with exposure of IAP. The prevalence of diseases and their symptoms may be influenced by other factors such as kitchen characteristics. Correlation analysis performed between prevalence of diseases and related symptoms versus different household characteristics revealed that ventilation size, door size, kitchen dimension were inversely related with prevalence of disease. Similarly, high prevalence of diseases was found in those households using kitchen without partition, while lower in separate and partitioned kitchen. Results were in accordance with findings of studies conducted in rural part of Nepal and India.[2,12]

Pandey's study, in two contiguous villages: Sundarijal and Bhadrabas in rural Nepal on domestic smoke pollution and respiratory function, reported that lung functions (FVC-force vital capacity, FEV1-force expiratory volume in one second, and FMEF 25-75 –force mid expiratory flow rate) varied significantly with levels of daily smoke exposure in smokers but not in non smokers. This result was probably due to the interaction between smoking and domestic smoke pollution on the respiratory system.[13] Similar results were also found in our study, we measured only PEFR. PEFR of both male and female significantly varied with both smoking habit and daily exposure duration (P<0.01)

Many studies in global arena on ARI concurred that domestic smoke pollution is a major contributing factor for the cases. We took hours spent near stove as a proxy variable to test the relation with ARI as by the Pandey and Kossove.[6,14] The present study's findings have shown a consistently positive association between domestic smoke pollution and acute respiratory infection at both observation of exposure level and parental smoking habit, however, result were significant in grade first episode (P<0.01) and moderate episode (P<0.05) only, but not in life-threatening severe grades in the both cases considering exposure level and parental habit. Severe grade III/IV did not vary with both proxies: exposure level and smoking habit. The finding's of previous study, in rural village Panchayats of Talku Dundechaur and Chhaimale and the adjacent villages of Dakshinkali and Phakel in rural Nepal in way back in 1989, have shown consistently positive association between domestic smoke pollution and acute respiratory infection, especially life threatening moderate and severe grades (P<0.01) in both exposure level and parental smoking habit.[7] This finding suggests that primary health care facility has played important role for controlling the acute respiratory infection, as the people used to go to the hospital when the disease was severe. However, household characteristics, kitchen dwelling behavior of parents with child and passive smoking by infants and children from parental smoking habit contributes toward development of respiratory tract infections in the children and infants.

This study determines the intensity of the problem of indoor air pollution in Malikarjun VDC, Nepal; and partially bridges the gap of baseline study in the study area. However, there are some limitations of the study, primary limitation being inability of measuring the pollutants like TSP (Total Suspended Particulate), PM10 (Particulate Matter of size below 10 µg) and others. Similarly, due to lack of clinical investigation to identify the disease some error in the estimation is admissible. Besides, proper sample size for PEFR analysis was deficit because of reluctance of respondents in using the meter.

CONCLUSIONS

There is significant relationship between exposure level to indoor smoke and respiratory disorder in both adults and children. It is mainly associated with lack of education and awareness coupled with lack of alternative energies and modern technologies in the households. It is solvable through the available technologies and proper awareness. An effective intervention addressing the wide range of issues on education, economic development and alternative energies can be highly relevant in solving the health problems caused by indoor air pollution.

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