

Study of Association between Exposure to Indoor Air Pollution and Chronic Obstructive Pulmonary Disease among Nonsmokers in a North Indian Population – A Case–Control Study

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Abstract

Background: Chronic obstructive pulmonary disease (COPD) is one of the most killing diseases worldwide. Tobacco smoking is still the most common single cause of COPD, but in developing countries such as India, indoor air pollution is one of the common etiological factors for COPD. This study was done to find out the association of various indoor pollution and COPD, especially in women who are exposed most due to the burning of domestic fuel. **Patients and Methods:** This is a case–control study in which 164 spirometry-confirmed COPD patients and 328 matched controls were studied. Various types of indoor air pollution were compared between cases and controls. **Results:** Of 164 cases, 72 cases (43.9%) had regular exposure to indoor air pollution. Common types of indoor air pollution were biomass fuel, wood smoke, coal smoke, and stove smoke. The odds of having indoor pollution such as biomass fuel exposure, wood exposure, coal, and stove in COPD patients were 3.16, 2.70, 2.45, and 2.05, respectively, in comparison to the control group. Except stove exposure, other indoor air pollutions were statistically significant with $P = 0.001$, 0.003 , and 0.02 , respectively. Longer time exposure in terms of number of years of biomass fuel exposure, wood exposure, and coal fuel exposure was statistically significant as compared to exposures in the control group with $P = 0.001$, 0.0009 , and 0.0006 , respectively. **Conclusion:** Indoor air pollutants (biomass fuel, coal, and wood smoke) are associated with the development of COPD, especially in the female population.

Keywords: Biomass fuel, coal exposure, indoor air pollution, wood exposure

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a systemic disease which results from interaction between gene and environment. Smoking in any form (cigarette, beedi, hukka, and cigar, etc.) is a major environmental risk factor for COPD. Every smoker does not develop COPD in his life time, and hence, genetics also play a role in modifying the risk of COPD in smokers.^[1] The diagnosis of COPD is done by spirometry in patients having respiratory symptoms and exposure of noxious particles. The presence of a postbronchodilator forced expiratory volume 1 s (FEV_1)/forced vital capacity <0.70 confirms the presence of persistent airflow limitation. The severity of

COPD is also assessed by spirometry as mild ($FEV_1 >80\%$), moderate ($FEV_1 50\%–79\%$), severe ($FEV_1 30\%–49\%$), and very severe ($FEV_1 <30\%$).

The WHO estimates COPD to be the 10th leading cause of disability-adjusted life-years in all countries. In worldwide, mortality due to COPD was 3.17 million in 2015 and out of

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it >90% of COPD deaths occurred in low- and middle-income countries.^[2]

Worldwide, the primary cause of COPD is exposure to tobacco smoke but in developing countries such as India, other risk factors such as indoor air pollution is one of the major risk factors for COPD. Exposure to indoor air pollution can also affect the unborn child and represent a risk factor for developing COPD later in life. Indoor air pollution mainly consists of biomass fuel, wood burning, and stove smoke, etc., used for cooking, especially in developing countries such as India where it accounts for up to 75% of the domestic energy supply.^[1]

Major biomass fuel used in India are firewood, dung cakes, agricultural crop residues (such as straw, grass, and shrubs), coal fuels, and kerosene used as fuel in the stove.^[2] Out of total energy produced from domestic fuel, only 18% is used in cooking, whereas 74% of the energy is dissipated as waste heat. Burning biomass fuels emits toxic substances such as small solid particles of size <2.5 μm (PM2.5) which can penetrate deeply into the lungs. Common noxious particles released during the incomplete combustion of organic matter are carbon monoxide, polyorganic and polyaromatic hydrocarbons such as benzopyrenes fluorine, pyrene, chrysene, benzoanthracene, and benzofluoranthene.^[3,4] These noxious particles cause inflammation in airway and alveoli which leads to irreversible parenchymal destruction such as emphysema and chronic bronchitis. Lung histopathology in COPD patients exposed to biomass fuel smoke had more pigment deposition and fibrosis (bronchial anthracofibrosis) as compared to the cigarette smoker COPD.^[5]

In India, still large population, especially women are getting exposed to indoor pollution which causes COPD and other respiratory problems. This study tried to evaluate the strength between indoor pollution and COPD, especially in women.

PATIENTS AND METHODS

The study was conducted in the Department of Pulmonary Medicine in King George Medical University, Lucknow, Uttar Pradesh. This observational case-control study was approved by the Institutional Ethical Committee.

The study population

Cases

These were patients of nonsmoker COPD with age >45 years confirmed by spirometry.

Controls

These were age (>45 years), sex- and socioeconomic status class-matched bystanders (friends and relatives) of patients coming to the Outpatient Department (OPD). For each COPD patient, two-matched controls were taken and interviewed at the same time. No non-COPD patient admitted or attending OPDs was taken as control. This was done to avoid a bias described by Berkson.

Sample size

Cases: 164; controls: 328.

Methods

After obtaining the informed and written consent, all patients and controls were interviewed to get the detail of various exposures as follows: passive smoking, indoor pollution, occupational exposure to dust/fumes, the presence of recurrent ear, nose, and throat disease, and a history of respiratory infection in childhood. The history of exposure to various noxious particles such as the type of exposure, frequency, and duration of exposure was taken in detail.

All patients were managed according to the GOLD guideline.

Statistical methods

The data were collected on a predesigned and pretested schedule was entered into the Microsoft Excel® for subsequent analysis. Continuous variables were recorded as mean \pm standard deviation. The difference between the means of two continuous variables was tested using *t*-tests. Categorical variables were recorded as frequencies. Associations were studied through the EpiInfo software Epi Info™ Build 7.2.2.16 (CDC, USA) by calculation of odds ratio (OR) and *P* value using the Chi-square test with or without Yates' correction, as applicable. A value of *P* < 0.05 was considered as statistically significant.

RESULTS

In this study, a total 164 patients of COPD who met the inclusion and exclusion criteria and twice the number of age-matched controls (328) were studied. Socioeconomic status of patients was determined by the Kuppuswamy scale.^[6] In this study, majority of population belonged to a rural area. The sociodemographic data are given in Table 1.

Table 1: Sociodemographic characteristics of patients of chronic obstructive pulmonary disease and controls

Characteristics	Cases (n=164)	Control (n=328)
Gender, n (%)		
Males	88 (53.65)	174 (53.04)
Females	76 (46.34)	154 (46.95)
Male:female ratio	1:1	1:1
Age, mean \pm SD		
All	55.90 \pm 9.98	55.03 \pm 9.31
Males	55.52 \pm 10.22	55.18 \pm 9.8
Females	56.34 \pm 9.82	54.85 \pm 8.37
Socioeconomic status, n (%)		
Upper (1)	16 (9.75)	32 (9.75)
Upper middle (2)	70 (42.68)	140 (42.68)
Lower middle (3)	20 (12.19)	40 (12.19)
Upper lower (4)	38 (18.29)	60 (18.29)
Lower (5)	28 (17.07)	56 (17.07)
Residence, n (%)		
Rural	120 (73.17)	240 (73.17)
Urban	44 (26.82)	88 (26.82)

SD: Standard deviation

Out of 164 COPD patients, 148 had one-risk factor exposure, whereas 16 patients had two-risk factor exposures. Since majority of our population was from a rural area, indoor pollution in the form of biomass fuel, stove exposure, and wood fire exposure was more common. Indoor pollution exposure was dominantly present in 72 patients of total 164 COPD patients (43.9%), whereas in the control group, domestic exposure was in only 64 out of 328 controls (19.5%). Figure 1 shows the distribution of exposure of various risk factors in nonsmoker COPD patients. Figure 2 shows the female predominance in indoor pollution exposure as Indian women, especially in rural areas, use biomass fuel for cooking. In other exposure groups, males are predominant.

The various indoor air pollution exposures found in the case of COPD and controls are shown in Table 2. Common domestic smoke exposures, especially in Indian women are biomass fuel, wood fire, coal, and stoves, etc., [Figure 3]. Women usually get multiple exposures with these noxious particles while cooking.

The odds of having biomass fuel smoke exposure among males were 4.25 while in the female it was 4.37 [Table 2]. Overall OR is 3.16. The odds of having other types of indoor pollution such as wood exposure, coal and stove exposure in COPD patients are 2.70, 2.45, and 2.05, respectively, in comparison to the control group. Among the above exposures, biomass fuel smoke, wood smoke exposure, and coal smoking were statistically significant with value of $P = 0.0001$, 0.003, and 0.02, respectively [Table 3].

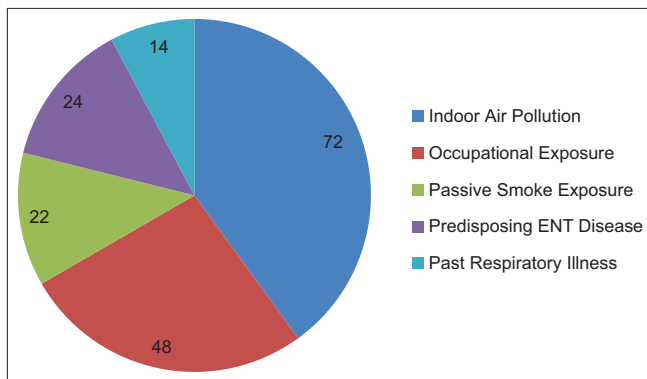


Figure 1: Risk factors exposure in chronic obstructive pulmonary disease patients

The duration of exposure for domestic smoke in our patients is given in Table 4. The mean duration of exposure for biomass fuel, wood exposure, coal, and stove smoke in cases was 3.44, 3.0, 2.14, and 2.75 h/day while in controls it was 3.31, 4.75, 3.0, 3.0 h/day. Only wood exposure and coal exposure difference was significant in COPD group compared to that of controls ($P = 0.038$ and 0.04). When the years of exposure was analyzed, except stove smoke exposure ($P = 0.091$), all other exposures were statistically significant in COPD patients as compared to controls.

DISCUSSION

Till recently, cigarette smoking was thought to be the major risk factor for COPD, but recent studies have shown nonsmoking factors are also a major risk factor for COPD. In a study done by Mahmood *et al.*, out of 200 confirmed COPD patients, there were 56.5% nonsmokers and 43.5% smokers.^[7] In developing countries such as India, coal, wood, and cow dung are major fuels used for cooking. Women and children have the highest amounts of exposures. Hence, biomass fuel smoke exposure is a major cause of COPD in women in developing countries. The biomass smoke acts as noxious particles and induces inflammatory response

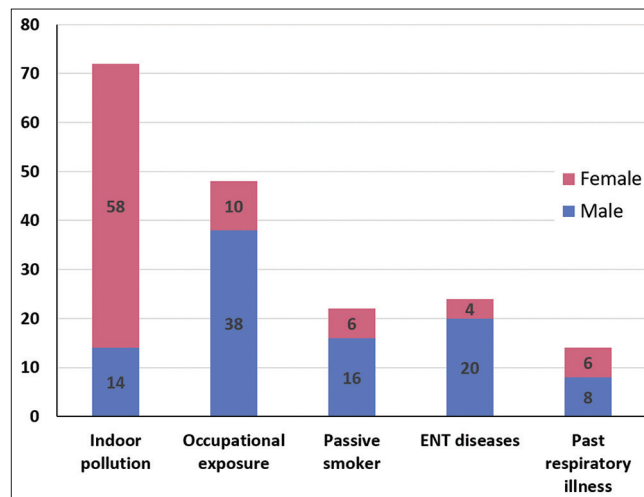


Figure 2: Female predominance in indoor pollution exposure as Indian women, especially in rural areas, use biomass fuel for cooking. In other exposure groups, males are predominant

Table 2: Distribution of various exposures among different classes of socioeconomic status in cases and control groups

Socioeconomic status	Cases (n=164)										Control (n=328)									
	Rural					Urban					Rural					Urban				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Biomass fuel	0	23	3	11	8	0	0	0	0	9	0	2	4	9	15	0	2	1	5	6
Wood exposure	0	2	2	11	4	0	0	0	0	1	0	0	0	1	10	0	0	0	3	2
Coal	0	0	2	9	3	0	0	0	0	0	0	0	0	6	2	0	0	0	3	1
Stove	0	0	1	5	2	0	0	0	0	0	0	0	1	4	0	0	0	1	2	0
Indoor air pollution	0	23	5	24	11	0	0	0	0	9	0	2	4	15	22	0	2	1	11	7

and tissue damage in airways. In genetically primed individuals, it causes irreversible obstructive airway disease.

In most studies, authors meant biomass fuel exposure as indoor pollution. We have segregated various types of indoor pollution in detail. Biomass fuel exposure is only one of the components of indoor pollution.

In a study by Mahmood *et al.*,^[7] among all nonsmoker COPD, biomass fuel exposure (indoor pollution) was in 53.98% patients, while in the present study, indoor pollution was 43.9% [Figure 1]. This difference can be attributed to the different type of population as the majority of this study population belonged to low-socioeconomic status (69.3%) as compared to the study population (35.3%) [Table 1].

Hu *et al.*,^[8] in their case-control study, showed OR of 2.44 (95% confidence interval [CI], 1.9–3.33) in biomass fuel exposure in developing COPD in comparison to controls, whereas in this study, OR was 3.16 [Table 3].

Pérez-Padilla *et al.*^[9] in the case-control study on exposure to biomass smoke and chronic airway disease in Mexican women found that OR for wood smoke exposure was 3.9 while in this study crude OR was 2.70, whereas in female population, it was 3.10 which is comparable with the above study.

In India, especially in rural area, women get higher domestic exposure as compared to the male population. Smith *et al.*^[10]

studied domestic exposure in women of age >30 years in rural areas and showed the relative risk 3.2 (95% CI 2.3–4.8) for COPD while Balmes^[11] showed relative risk of 1.78 (95% CI 1.45–2.18) in the same type of population. June Y T Po took 25 studies in their meta-analysis of indoor pollution, they showed OR of 2.40 (95% CI 1.47–3.93) in the female population. While in this study, OR was 5.63 [Table 3].^[12] This wide difference in various studies was due to smoke quality or fuel quality and emitted smoke from those fuels.

Moreira *et al.* studied smoke from wood combustion in Brazilian female population, they showed that the COPD group had greater exposure in years to wood smoke ($P = 0.043$) than the control group. In this study also numbers of years exposed to wood combustion is statistically significant ($P = 0.0009$) [Table 4].^[13]

In this study, we found that the long-term biomass fuel exposure and coal smoke exposure in terms of number of years are hazardous in COPD group as compared to the control group ($P = 0.0001$, 0.0009, and 0.0006, respectively). This finding was supported by Pérez-Padilla *et al.*^[9] who found that risk of COPD increased in early age with hours-years of cooking. OR in patients exposed for ≥ 200 h years compared with that in nonexposed was 15 for COPD disease and 75 for COPD with chronic airway obstruction.

Smith *et al.* also studied pediatric age group of <5 years in the rural area and showed relative risk for acute lower respiratory disease was 2.3 (95% CI 1.9–2.7).^[10] This shows that children living in indoor air pollution environment are not safe and in the long term, they are more likely to get COPD.

Limitation in study

This study was not able to estimate the association of COPD with indoor pollution in general population as smokers were excluded from the current study.

CONCLUSION

Indoor air pollution such as burning of biomass fuel, wood exposure, and coal fuel exposure are associated with COPD in the nontobacco smoker group. Good ventilation and alternative cooking fuels such as liquid petroleum gas may reduce the incidence of COPD in the developing world.

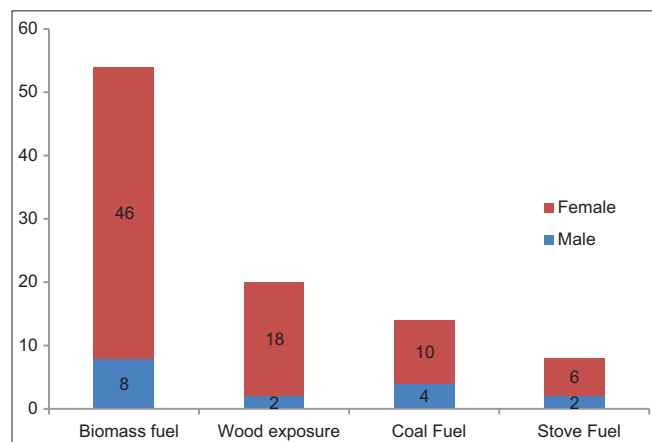


Figure 3: Gender distribution of various indoor air pollutants

	Male (262)			Female (230)			P	Crude OR (95% CI)
	Case (88)	Control (174)	OR (95% CI)	Case (76)	Control (154)	OR (95% CI)		
Biomass fuel	8 (9.09)	4 (2.30)	4.25 (1.24-14.53)	46 (60.53)	40 (25.97)	4.37 (2.44-7.84)	0.0001	3.16 (2.01-4.99)
Wood exposure	2 (2.27)	2 (1.15)	2.0 (0.28-14.44)	18 (23.68)	14 (9.09)	3.10 (1.45-6.65)	0.003	2.70 (1.36-5.38)
Coal	4 (4.55)	2 (1.15)	4.10 (0.74-22.81)	10 (13.16)	10 (6.49)	2.18 (0.87-5.50)	0.02	2.45 (1.11-5.44)
Stove	2 (2.27)	2 (1.15)	2.0 (0.28-14.44)	6 (7.89)	6 (3.90)	2.11 (0.66-6.79)	0.150	2.05 (0.76-5.57)
Indoor air pollution (overall)	14 (15.91)	8 (4.60)	3.92 (1.58-9.76)	58 (76.32)	56 (36.36)	5.64 (3.03-15.51)	0.001	3.22 (2.14-4.87)

OR: Odds ratio, CI: Confidence interval

Table 4: Duration of exposure for domestic smoke exposure

	COPD cases		Control		P
	n	Mean±SD	n	Mean±SD	
Biomass fuel					
Number of years	54	3.44±0.697	44	3.31±0.716	0.504
Number of hours per day	54	20.92±4.81	44	11.36±4.46	0.0001
Wood exposure					
Number of years	20	3.0±0.47	16	4.75±2.25	0.038
Number of hours per day	20	24±4.59	16	15.37±4.27	0.0009
Coal					
Number of years	14	2.14±0.377	12	3.0±0.894	0.04
Number of hours per day	14	27±4.8	12	13.85±5.3	0.0006
Stove					
Number of years	8	2.75±0.5	8	3.0±0	0.317
Number of hours per day	8	20±8.16	8	10±0	0.091

SD – Standard deviation, COPD – Chronic obstructive pulmonary disease

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Conflicts of interest

There are no conflicts of interest.

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