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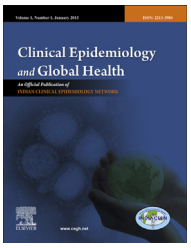

Original Article

Environmental risk factors for asthma in Lucknow: A case–control study

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ABSTRACT

Problem considered: The primary objective was to identify the risk factors for asthma among common environmental exposures, motor vehicle air pollution, industrial smoke, current smoking, passive smoking and an exposure to environment tobacco smoke (ETS) as compared to non-asthmatic controls. The secondary objective was to find out association of these environmental exposure with severity of asthma along with the factors, allergy to dust, hospitalization and family history of asthma.

Methods: Subjects aged 1–50 years with asthma and non-asthmatic controls were recruited in a case–control format, according to Global Initiative for Asthma guidelines (GINA). Data collection was done using standard questionnaire. For the uniformity of data, we grouped recruited population in two groups; 1) age $\leq$ 15 years and 2) age $>$ 15 years. Both the groups were age and sex matched.

Results and conclusion: On analyzing age group $\leq$ 15 years, we observed association of motor vehicle air pollution [Odds ratio (OR) = 2.7; 95% Confidence Interval (CI) = 1.4–5.3; *P* value = 0.003], industrial smoke [OR = 2.9; 95%CI = 1.3–6.9; *P* = 0.013], and exposure to ETS [OR = 6.6; 95%CI = 4.1–10.7; *P* < 0.001] with asthma as compared to controls. On analyzing age group > 15 years, we also observed an association of factors motor vehicle air pollution [OR = 1.6; 95%CI = 1.1–2.6; *P* = 0.029], industrial smoke [OR = 2.7; 95%CI = 1.2–5.8; *P* = 0.012], current smoking [OR = 2.6; 95%CI = 1.7–3.8; *P* < 0.001] and passive smoking [OR = 2.4; 95%CI = 1.6–3.6; *P* < 0.001] to be associated with asthma. For severity association we did "case only" analysis and observed only factor "hospitalization of asthma" to be statistically significantly associated with the severity of disease (*P* < 0.05).

1. Introduction

Asthma is a common, chronic disease that affects approximately 300 million individuals worldwide,[1] defined as chronic inflammatory disorder of the airways that leads to recurrent episodes of wheezing, breathlessness, chest tightness and coughing, particularly at night or in the early morning. These episodes are associated with airway hyperresponsiveness,

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variable airflow obstruction that occurs often reversible either spontaneously or with treatment.[2] In India, the prevalence of asthma in adults is 2.38%[3] that differs from 3 to 31% in children.[4,5] Subbarao et al, reviewed epidemiology, etiology and risk factors for disease asthma and found many other factors like maternal smoking, diet and nutrition, stress, use of antibiotics, delivery by cesarean section, allergic sensitization, environmental tobacco smoke, exposure to animals, breastfeeding, decreased lung function in infancy, family size and structure, socio-economic status, antibiotics and infections, and sex to be associated with disease asthma.[6] Literature suggests major risk factors for asthma such as; tobacco smoke, active and passive smoking, air pollution (including dust, pollution, smoke emitting industries, traffic pollution that is also linked to severe asthma attacks).[7–29] A study by Gupta and Bala in the year 2011 concluded, Indian output on asthma is quite low in the global context as reflected from its publications output per thousand populations and its world population share during 1999–2008.[6] Keeping in mind all the factors we aimed: 1) to identify the risk factors for asthma among common environmental exposures, motor vehicle air pollution, industrial smoke, current smoking, passive smoking and exposure to ETS as compared to non-asthmatic controls, 2) to find out association of these environmental exposure with severity of asthma along with the factors, allergy to dust, hospitalization and family history of asthma.

2. Methods

2.1. Setting/characterization of phenotype

From August 2007 to September 2009, a case–control study was conducted at the Departments of Pulmonary Medicine and Pediatrics of King George Medical University (KGMU), Lucknow, Uttar Pradesh. The study was approved by the institutional ethics committee and written informed consent for participation was obtained from all the patients and controls.

2.2. Cases

All the subjects who came for medical check-up in the departments of Pulmonary Medicine and Pediatrics of KGMU from August 2007 to September 2009 were screened for suitability for inclusion in the study. The diagnosis and classification of the asthma and its severity was made according to GINA.[2] Inclusion criteria for cases were (a) diagnosis of asthma according to the treating physician, (b) symptoms, (c) use of medications for asthma, (d) reversible airflow limitation according to GINA guidelines; FEV1 reversibility $>$ 12% and 200 ml after a post bronchodilator spirometry.[30]

For $<$6 years of age, spirometry was not possible therefore diagnosis of asthma was based on the presence of clinical symptoms as given in GINA guidelines. However, for stringent criteria of selecting asthma under this age group, cases were recruited that were presence of two or more of the following symptoms: a) current presence of wheeze in any child with a history of more than two episode of documented wheeze or use of bronchodilator in the preceding 12 months, b) on any regular medication for asthma such as corticosteroids, b-2 agonist, methyl xanthines, leukotriene modifiers and cromones, c) presenting with symptoms of asthma along with positive family history of asthma.[30]

2.3. Controls

Controls were persons attending OPD from the same locality/community with other ailments. The inclusion criteria for controls were: (a) no past or present diagnosis of asthma and other pulmonary diseases (b) no history of wheezing, shortness of breath, and other symptoms of allergic diseases such as nasal and skin symptoms; (c) no use of medications for asthma; and (d) absence of first-degree relatives with a history of asthma.

2.4. Statistical analysis

Data was entered in Microsoft Excel and analyzed using statistical software SPSS version 11.5 (Chicago, IL, USA). Mean and Standard Deviation (SD) were calculated for continuous variables and proportions were calculated for categorical variables. For assessing the association of risk factors with asthma and severity, we used chi-square test with 2 degree of freedom for categorical variables and student's t test for continuous variables. We calculated odd's odds ratio with 95% confidence interval using Logistic Regression model. Variables that were entered in the logistic regression model to find association with asthma and its severity were those which on univariate analysis were found to be associated with persistent asthma with P value < 0.05. Using a 2-tailed distribution, P value of <0.05 was considered statistically significant. For analyzing associated factors with the severity of asthma, a "case only" study was performed.

We recruited cases and controls between the age group of 1 and 50 years. For the uniformity of data we grouped recruited population in two groups; 1) age $\leq$ 15 years and 2) age $>$ 15 years. Both the groups were age and sex matched.

Analysis was done to find out any association for gender, anthropometry, place of residance (rural or urban), type of family (joint and nuclear), birth order, $\leq$2 and $>$2 (where birth order was defined as, >2 = subjects that had 2 or more younger siblings, ≤ 2 = subject either was first or second baby of their parents), separate cooking space, use of biomass fuel other that Liquid Petroleum Gas (LPG), non-vegetarian diet, motor vehicle air pollution (distance from heavy traffic in km, where heavy traffic was defined as road with 24 h vehicular traffic movement emitting exhaust fumes,[30] industrial smoke (industrial area with emission of smoke within 1.5 km of residence), current smoking habit (active smokers), passive smoke (friend's, father's or other close family member's smoking behavior including average number of cigarette or "bidi" smoked indoor daily), ETS. Severity of asthma was analyzed with these factors along with the family history of asthma (maternal and paternal), hospitalization for asthma and allergy to dust (allergy to dust was defined as episode of sneezing, coughing, redness of eyes, itching after exposure to dust and subsiding soon after removing exposure, with reappearance on re-exposure).

2.5. *Measurement of ETS*

For measurement of residential ETS exposure, subjects were requested to answer regarding "current smokers" in their home who smoked in their presence. Children's parents were requested to answer on their behalf. Hence categories were defined for easy recall for range of average number of cigarettes/bidis smoked per day per person. The median value of the range was multiplied by the number of smokers to give the 'Exposure Index' (EI). EI was calculated assuming that all the subjects aged ≤ 15 years were exposed to passive smoke.[16]

3. Result

Included in the study were 390 controls and 386 cases of asthma. Among recruited cases 95 (24.6%) had mild intermittent, 235 (60.9%) had mild persistent and 56 (14.5%) had moderate persistent asthma. The baseline characteristics are given in Table 1. Average number of patients recruited per month is shown in Fig. 1. On an average, maximum patients were recruited in month of, July (N = 29), March (N = 24) and August (N = 23). Least number of patients was recruited in the month February (N = 5).

3.1. *Case–control association*

Recruited data were compared between cases and controls for both the groups separately. Table 2 illustrates an overview of study population of age group ≤ 15 years and Table 3 represents characteristics of population of age group > 15 years. Table 4 represents logistic regression analysis to assess the risk factors for asthma in groups; ≤15 and >15 years of age for the variables that were found to be associated with asthma.

3.1.1. *Age group ≤15 (in years)*

In this group none of the recruited subjects had exposure of active smoking. After analyzing data we found subjects who were living in joint families [OR = 1.6; 95%CI = 1.0–2.5; P = 0.035], subjects who were in touch with motor vehicle air pollution and industrial smoke [(OR = 2.7; 95%CI = 1.4–5.3; P = 0.003); (OR = 2.9; 95%CI = 1.3–6.9; P = 0.013), respectively], and subjects who had exposure to ETS [OR = 6.6; 95% CI = 4.1–10.7; P < 0.001], had more chances to develop risk for disease asthma.

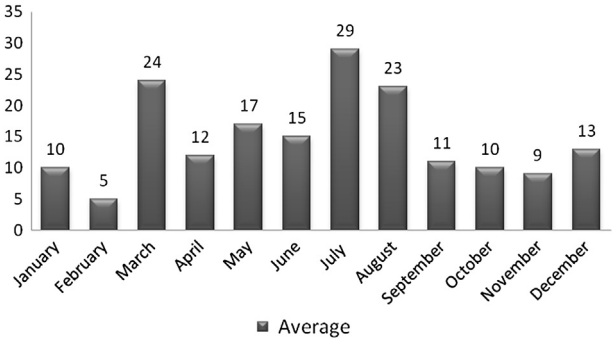

Fig. 1 – Average number of patients recruited per month, from August 2007 to September 2009.

3.1.2. *Age group >15 (in years)*

In this group recruited subjects presented with current (active) smoking habit. Therefore smoking status of recruited subjects was recorded along with second hand smoking (passive smoking). We observed subjects having birth order > 2 (OR = 5.5; 95%CI = 2.8–10.7; P < 0.001), subjects who were in touch with motor vehicle air pollution and industrial smoke [(OR = 1.6; 95%CI = 1.1–2.6; P = 0.029) and (OR = 2.7; 95% CI = 1.2–5.8; P = 0.012), respectively], subject presenting with current smoking status (OR = 2.6; 95%CI = 1.7–3.8; P < 0.001) and those had exposure to second hand smoke (OR = 2.4; 95% CI = 1.6–3.6; P < 0.001), had more chances to develop risk for disease asthma.

4. Association on the basis of severity of asthma

For analyzing severity we compared each persistent groups named as, mild persistent and moderate persistent with mild intermittent separately.

Table 1 – Baseline characteristic of study population.

Basic demographic	(N = 776)				
	Controls (390)	Cases (386)	Severity subgroups of asthma (N)		
			Mild intermittent (95)	Mild persistent (235)	Moderate persistent (56)
1. Gender (F) N (%)	127 (32.6)	122 (31.6)	28 (29.5)	73 (31.1)	21 (37.5)
2. Age (in years) M ± SD	22.9 ± 14.5	18.7 ± 15.9	18.3 ± 13.9	18.2 ± 15.8	21.3 ± 19.6
3. Weight (in kg) M ± SD	46.8 ± 22.9	36.5 ± 22.4	37.2 ± 21.1	36.4 ± 22.4	35.9 ± 24.6
4. Height (in cm) M ± SD	145.5 ± 28.9	133.3 ± 30.8	136.4 ± 29.3	132.4 ± 31.9	131.9 ± 28.5
5. BMI M ± SD	20.0 ± 5.4	18.3 ± 6.6	17.9 ± 4.7	18.5 ± 7.3	18.1 ± 6.5
6. Hospitalization for asthma N (%)	NA	157 (40.7)	14 (14.7)	102 (43.4)	41 (73.2)
7. Family history of asthma N (%)	NA	174 (45.1)	44 (46.3)	102 (43.4)	28 (50.0)

F = female; N = number; % = percentage; M ± SD = mean ± standard deviation.

Table 2 – Distribution of variables between cases and controls for age group ≤15 (in years).

Demographic characteristic	Cases N = 211 (%)	Controls N = 137 (%)	P value
Age group ≤15			
Age (in years)	6.2 ± 3.8	6.1 ± 3.5	0.873
Sex (female)	68 (32.2)	41 (29.9)	0.723
Weight (in kg)	18.4 ± 8.6	18.8 ± 9.6	0.659
Height (in cm)	109.9 ± 22.2	110.8 ± 20.1	0.723
BMI	14.9 ± 6.5	14.7 ± 4.1	0.622
Belongs to			
Rural	42 (19.9)	18 (13.1)	
Urban	169 (80.1)	119 (86.9)	0.112
Family type			
Joint	148 (70.1)	81 (59.1)	
Nuclear	63 (29.9)	148 (70.1)	0.038
Birth order			
≤2	45 (21.3)	26 (19.0)	
>2	166 (78.7)	111 (81.0)	0.683
Cooking space			
Yes	204 (96.7)	135 (98.5)	
No	7 (3.3)	2 (1.5)	0.492
Use of biomass fuel other than LPG for cooking			
Yes	39 (18.5)	37 (27.0)	
No	172 (81.5)	100 (73.0)	0.064
Motor vehicle air pollution			
No	164 (77.7)	124 (90.5)	
Yes	47 (22.3)	13 (9.5)	0.002
Industrial Smoke (yes)	29 (13.7)	7 (5.1)	0.011
Non-vegetarian	126 (59.7)	83 (60.6)	0.911
Smoking status			
Environment tobacco smoke (ETS)			
Exposure index (EI)			
≤5 EI	82 (38.9)	102 (74.5)	<0.001
6–10 EI	52 (24.6)	24 (17.5)	
>10 EI	77 (36.5)	11 (8.0)	

F = female; N = number; % = percentage; M ± SD = mean ± standard deviation; Birth order > 2 = subjects that had 2 or more younger siblings, ≤2 = subject either was first or second baby of their parents; EI – exposure index (median of range of No. of bidis and cigarettes smoked per person per day multiplied by No. of family members smoking).

Table 3 – Distribution of variables between cases and controls for age group >15 (in years).

Demographic characteristic	Cases N = 175 (%)	Controls N = 253 (%)	P value
Age group >15 (in years)			
Age (in years)	33.66 ± 11.32	31.93 ± 9.22	0.082
Sex (female)	54 (30.9)	86 (34.0)	0.530
Weight (in kg)	33.66 ± 11.32	31.93 ± 9.22	0.037
Height (in cm)	161.41 ± 7.27	164.23 ± 7.88	0.733
BMI	22.34 ± 4.07	22.94 ± 3.51	0.106
Belongs to			
Rural	49 (28.0)	70 (27.7)	
Urban	126 (72.0)	183 (72.3)	1.000
Family type			
Joint	103 (58.9)	131 (51.8)	
Nuclear	72 (41.1)	122 (48.2)	0.167
Birth order			
≤2	11 (6.3)	68 (26.9)	
>2	164 (93.7)	185 (73.1)	<0.001
Cooking space			
Yes	172 (98.3)	249 (98.4)	
No	3 (1.7)	49 (1.6)	1.000
Use of biomass fuel other than LPG for cooking			
Yes	33 (18.9)	32 (12.6)	
No	142 (81.1)	221 (87.4)	0.100
Motor vehicle air pollution			
No	122 (69.7)	200 (79.1)	
Yes	53 (30.3)	53 (20.9)	0.031
Industrial smoke (yes)	19 (10.9)	11 (4.3)	0.012
Non-vegetarian	116 (66.3)	156 (61.7)	0.359
Smoking status*			
Subject (active or current smoking)			
1–2	23 (13.1)	28 (11.1)	0.001
3–10	28 (16.0)	16 (6.3)	
>10	36 (20.6)	26 (10.3)	
Non-smoker	88 (50.3)	183 (72.3)	
Total current smoking (yes)	87 (49.7)	70 (27.7)	<0.001
Other family member' (passive smoking)			
1–2	44 (25.1)	30 (11.9)	0.001
3–10	20 (11.4)	34 (13.4)	
>10	25 (14.3)	12 (4.7)	
Non-smoker	86 (49.1)	177 (70.0)	
Total current smoking (yes)	89 (50.9)	76 (30.0)	<0.001

F = female; N = number; % = percentage; M ± SD = mean ± standard deviation; Birth order > 2 = subjects that had 2 or more younger siblings, ≤2 = subject either was first or second baby of their parents.
* = Number of cigarette or "bidi" smoked per day.

4.1. *Age group ≤15 (in years)*

In this group among recruited 211 cases, 51 (24.2%) were mild intermittent, 127 (60.2%) were mild persistent and 33 (15.6%) were moderate persistent (Table 5).

After analyzing data, we observed that hospitalization for asthma to be statistically associated with the severity of disease [mild intermittent vs mild persistent (OR = 4.9; 95% CI = 2.3–10.5; $P < 0.001$) and mild intermittent vs moderate persistent (OR = 20.4; 95%CI = 6.4–65.1; $P < 0.0001$)].

Two factors not statistically significant, however had tendency to be associated with severity of asthma; 1) living place of residence (rural and urban) [mild intermittent vs mild persistent (OR = 1.5; 95%CI = 0.7–3.1; $P = 0.357$) and mild intermittent vs moderate persistent (OR = 5.9; 95% CI = 1.2–27.8; $P = 0.026$)]; and 2) cases who has presence of maternal family history of asthma [mild intermittent vs mild persistent (OR = 1.8; 95%CI = 0.8–2; $P = 0.141$) and mild intermittent vs moderate persistent (OR = 2.7; 95% CI = 0.9–7.3; $P = 0.057$)].

These associations were more significant in moderate persistent category as compared to its associations with mild persistent. This indicates that association was related to increasing severity of asthma.

4.2. *Age group >15 (in years)*

In this group among recruited 175 cases, 44 (25.1%) were mild intermittent, 108 (61.7%) were mild persistent and 23 (13.1%) were moderate persistent (Table 6).

We observed that patients having moderate persistent asthma were older in age [mild intermittent vs mild

Table 4 – Logistic regression analysis to assess the risk factors for asthma in groups ≤15 and >15 years of age.

Variable (coding)	OR (95%CI) *P* value	OR (95%CI) *P*-value
	Age group ≤15 (in years)	Age group >15 (in years)
Family type		
Nuclear (0)	Reference 1	Reference 1
Joint (1)	1.6 (1.0–2.5) 0.035	Reference 1
Birth order		
≤2 (0)	Reference 1	Reference 1
>2 (1)	Reference 1	5.5 (2.8–10.7) < 0.001
Motor vehicle air pollution		
Yes (0)	Reference 1	Reference 1
No (1)	2.7 (1.4–5.3) 0.003	1.6 (1.1–2.6) 0.029
Industrial smoke		
No (0)	Reference 1	Reference 1
Yes (1)	2.9 (1.3–6.9) 0.013	2.7 (1.2–5.8) 0.012
Smoking status*		
Environment tobacco smoke (ETS)		
Exposure index (EI)		
≤5 EI (0)	Reference 1	NA
6–10 EI (1)	2.7 (1.5–4.7) 0.001	
>10 EI (2)	8.7 (4.3–17.5) 0.000	
Total (yes)	6.6 (4.1–10.7) < 0.001	
Current smoking habit (active smoking)		
1–2 (0)	NA	Reference 1
3–10 (1)		2.1 (0.9–4.9) 0.073
>10 (2)		1.7 (0.8–3.6) 0.171
Total current smokers (Yes = 1; No = 0)	NA	2.6 (1.7–3.8) < 0.001
Other family member's smoking habit (passive smoking)		
1–2 (0)	NA	Reference 1
3–10 (1)		0.4 (0.2–0.8) 0.013
>10 (2)		1.4 (0.6–3.3) 0.407
Total current smoking (Yes = 1; No = 0)	NA	2.4 (1.6–3.6) < 0.001

Birth order >2 = subjects that had 2 or more younger siblings, ≤2 = subject either was first or second baby of their parents; EI – Exposure Index (median of range of No. of bidis and cigarettes smoked per person per day multiplied by No. of family members smoking); NA = not applicable.
* = Number of cigarette or "bidi" smoked per day.

persistent: $P = 0.462$; mild intermittent vs moderate persistent: $P < 0.001$). Motor vehicle air pollution was more likely to be associated with disease severity [mild intermittent vs mild persistent (OR = 2.4; 95%CI = 0.9–5.9; $P = 0.054$) and mild intermittent vs moderate persistent (OR = 5.8; 95% CI = 1.8–18.2; $P = 0.003$)]. Similar as age group ≤ 15 (in years), in this group also admission in hospitals was related to severity of asthma [mild intermittent vs mild persistent (OR = 5.0; 95%CI = 1.4–17.5; $P = 0.011$) and mild intermittent vs moderate persistent (OR = 17.8; 95%CI = 4.2–74.5; $P < 0.001$)]. Positive family history of asthma had statistically significant association with mild persistent asthma (OR = 2.3; 95% CI = 1.1–4.7; $P = 0.022$), moreover paternal family history was found to be statistically associated with mild persistent subgroup of asthma (OR = 3.3; 95%CI = 1.5–7.2; $P = 0.002$), however these associations were not related to severity of asthma as we did not observe similar association with moderate persistent group of asthma.

5. Discussion

Study was done to identify the risk factors for asthma and its severity among recruited 386 cases and 390 non-asthmatic controls, aged 1–50 years.

On analyzing case–control data we observed association of motor vehicle air pollution, industrial smoke, smoking (active and passive), and exposure to ETS with risk of asthma. Additionally, subjects of age group ≤ 15 years, those were living in joint families had more chances to have risk of asthma. Whereas in subjects of age group > 15 years, having birth order >2 was found to be associated with risk of asthma.

Many studies have observed risk factors for asthma in children[8] and adults[9] separately, that shows risk factors may affects differently at different age groups. However, in our study we almost got similar results in both the studied groups; ≤15 and >15 years of age.

5.1. *Association of "motor vehicle air pollution" and "industrial smoke" in disease asthma*

Similar to our results, there is now a large body of literature supporting a linkage between exposure to air pollutants and asthma morbidity.[10–12] A meta-analysis observed, living or attending schools near high traffic density roads increases the incidence and prevalence of childhood asthma and wheeze.[13] Similarly another meta-analysis for all ages observed, about half of all mortality caused by air pollution was attributed to motorized traffic.[14] Likely to our results, many other studies also have shown pollution of heavy traffic[10,15] as major risk

Table 5 – Association of variables among severity subgroups of asthma in age group ≤15 years.

Severity of asthma	Mild intermittent N (%) = 51 (24.2)	Mild persistent N (%) = 127 (60.2)	Intermittent vs mild persistent	Moderate N (%) = 33 (15.6)	Intermittent vs moderate persistent
Age group ≤15 (in years)					
Age (in years)	7.1 ± 4.1	5.7 ± 3.9	0.039	6.4 ± 2.9	0.409
Sex (female)	37 (29.1)	18 (35.3)	0.474	13 (39.4)	0.818
Weight (in kg)	19.7 ± 8.5	18.0 ± 9.1	0.246	17.6 ± 6.2	0.215
Height (in cm)	113.9 ± 21.7	107.8 ± 23.2	0.105	112.1 ± 18.4	0.677
BMI	14.6 ± 2.5	15.4 ± 8.1	0.521	13.8 ± 2.8	0.175
FEV1 (% predicted)	78.0 ± 1.5	65.9 ± 4.8	<0.001	57.9 ± 2.7	<0.001
Belongs to					
Rural	14 (27.5)	26 (20.5)	–	2 (6.1)	–
Urban	37 (72.5)	101 (79.5)	0.326[1]	31 (93.9)	0.021[2]
Family type					
Joint	28 (54.9)	97 (76.4)	–	23 (69.7)	–
Nuclear	23 (45.1)	30 (23.6)	0.006	10 (30.3)	0.253
Birth order					
≥2	14 (27.5)	27 (21.3)	–	29 (87.9)	–
<2	37 (72.5)	100 (78.7)	0.432	4 (12.1)	0.110
Cooking space					
Yes	47 (92.2)	124 (97.6)	–	33 (100.0)	–
No	4 (7.8)	3 (2.4)	0.105	0 (0)	0.151
Use of biomass fuel other than LPG for cooking					
Yes	13 (25.5)	21 (16.5)	–	5 (15.2)	–
No	38 (74.5)	106 (83.5)	0.206	28 (84.8)	0.291
Motor vehicle air pollution					
No	35 (68.6)	100 (78.7)	–	29 (87.9)	–
Yes	16 (31.4)	27 (21.3)	0.177	4 (12.1)	0.065
Industrial smoke (yes)	9 (17.6)	19 (15.0)	0.654	1 (3.0)	0.080
Non-vegetarian	37 (72.5)	69 (54.3)	0.029	37 (72.5)	0.339
Smoking status (passive smoking)					
Environment tobacco smoke (ETS)					
Exposure index (EI)					
1–5 EI	17 (33.3)	48 (37.8)	0.579	17 (51.5)	0.189
5–10 EI	15 (29.4)	28 (22.0)		9 (27.3)	
>10 EI	19 (37.3)	51 (40.2)		7 (21.2)	
Clinical variables					
Allergy to dust	34 (66.7)	68 (53.5)	0.132	15 (45.5)	0.071
Seasonal variation	48 (94.1)	109 (85.8)	0.197	27 (81.8)	0.145
Hospitalization for asthma	11 (21.6)	73 (57.5)	<0.001[3]	28 (84.8)	<0.0001[4]
Family history of asthma	17 (33.3)	58 (45.7)	0.179	16 (48.5)	0.179
Maternal family history	9 (17.6)	36 (28.3)	0.182[5]	12 (36.4)	0.072[6]
Paternal family history	29 (22.8)	8 (15.7)	0.316	6 (18.2)	0.772

F = female; n = number; % = percentage; M ± SD = mean ± standard deviation; Birth order > 2 = subjects that had 2 or more younger siblings, ≤2 = subject either was first or second baby of parents; 1 = [OR = 1.5 (95%CI, 0.7–3.1) 0.357]; 2 = [OR = 5.9 (95%CI, 1.2–27.8) < 0.026]; 3 = [OR = 4.9 (95%CI, 2.3–10.5) P < 0.001]; 4 = [OR = 20.4 (95%CI, 6.4–65.1) P < 0.0001]; 5 = [OR = 1.8 (95%CI, 0.8–0.2) P = 0.141]; 6 = [OR = 2.7 (95%CI, 0.9–7.3) P = 0.057]; EI – exposure index (median of range of No. of bidis and cigarettes smoked per person per day multiplied by No. of family members smoking).

factors to cause asthma and risk of developing severity of asthma at different region of world.

5.2. *Association of "current, passive smoking and exposure to ETS" with asthma*

Similar to our results, there are a number of studies examining rates of co-occurring asthma and smoking.[16,20] Zbikowski et al found that those with either current or past asthma were nearly 1.5 times more likely than those without asthma to smoke at least on a monthly basis. However, passive smoke did not differ between those with and without asthma.[17] However contrast to our results, few studies have been reported no differences in smoking rates between those with and without asthma.[18,19]

5.3. *Association between "joint families" and "asthma"*

Subjects, aged ≤ 15, those were living in joint families had more chances to have asthma. However, none of the published study has shown this type of association so far. Affect of passive smoking on younger age family members perhaps one of the reasons in joint families for having risk of asthma.[20] As in our study we did not observe this association with subjects aged >15. The reason might be that association between parental second hand smoke (passive smoking)

Table 6 – Association of variables among severity subgroups of asthma in age group >15 years.

Severity of asthma	Mild intermittent N (%) = 44 (25.1)	Mild persistent N (%) = 108 (61.7)	Intermittent vs mild persistent	Moderate N (%) = 23 (13.1)	Intermittent vs moderate persistent
Age group >15 years					
Age (in years)	31.31 ± 8.9	32.72 ± 11.37	0.462	42.57 ± 11.42	<0.001
Sex (female)	10 (22.7)	36 (33.3)	0.244	8 (34.8)	0.385
Weight (in Kg)	57.41 ± 10.59	57.95 ± 11.47	0.787	62.13 ± 15.39	0.145
Height (in cm)	162.39 ± 6.54	161.22 ± 7.07	0.348	160.43 ± 9.42	0.324
BMI	21.74 ± 3.62	22.27 ± 3.82	0.494	24.09 ± 5.47	0.324
FEV1 (% predicted)	93.25 ± 1.6	87.5 ± 4.2	<0.001	74.26 ± 3.19	<0.001
Belongs to					
Rural	11 (25.0)	31 (28.7)	–	7 (30.4)	–
Urban	33 (75.0)	77 (71.3)	0.694	16 (69.6)	0.773
Family type					
Joint	24 (54.5)	64 (59.3)	–	15 (65.2)	–
Nuclear	20 (45.5)	44 (40.7)	0.593	8 (34.8)	0.445
Birth order					
≥2	3 (6.8)	5 (4.6)	–	3 (13.0)	–
<2	41 (93.2)	103 (95.4)	0.691	20 (87.0)	0.406
Cooking space					
Yes	43 (97.7)	108 (100.0)	–	21(91.3)	–
No	192.3	0 (0)	0.289	2 (8.7)	0.269
Use of biomass fuel other than LPG for cooking					
Yes	9 (20.5)	20 (18.5)	–	4 (17.4)	–
No	35 (79.5)	88 (81.5)	0.821	19 (82.6)	1.000
Motor vehicle air pollution					
No	37 (84.1)	74 (68.5)	–	11 (47.8)	–
Yes	7 (15.9)	34 (31.5)	0.069[1]	12 (52.2)	0.004[2]
Industrial smoke (yes)	3 (6.8)	14 (13.0)	0.397	2 (8.7)	1.000
Non-vegetarian	26 (59.1)	74 (68.5)	0.346	16 (69.6)	0.438
Smoking status*					
Subject (active or current smoking)					
1–2	9 (20.5)	8 (7.4)	0.088	6 (26.1)	0.503
3–10	8 (18.2)	16 (14.8)		4 (17.4)	
>10	5 (11.4)	27 (25.0)		4 (17.4)	
Non-smoker	22 (50.0)	57 (52.8)		9 (39.1)	
Total current smokers	22 (50.1)	51 (10.2)	0.575	2 (8.7)	0.705
Father/other family member (passive smoking)					
1–2	9 (20.5)	27 (25.0)	0.085	8 (34.8)	0.114
3–10	3 (6.8)	15 (13.9)		2 (8.7)	
>10	3 (6.8)	19 (17.6)		3 (13.0)	
Non-smoker	29 (65.9)	47 (43.5)		10 (43.5)	
Total current smokers	15 (34.1)	61 (56.5)	0.012	13 (56.5)	0.077
Clinical variables					
Allergy to dust	9 (20.5)	24 (22.2)	1.000	5 (21.7)	1.000
Seasonal variation	41 (93.2)	91 (84.3)	0.188	21 (91.3)	1.000
Hospitalization for asthma	3 (6.8)	29 (26.9)	0.007[3]	13 (56.5)	<0.001[4]
Family history of asthma	27 (61.4)	44 (40.7)	0.031[5]	12 (52.2)	0.603
Maternal family history	12 (27.3)	28 (25.9)	0.842	5 (21.7)	0.770
Paternal family history	19 (43.2)	20 (18.5)	0.002[6]	7 (30.4)	0.429

F = female; N = number; % = percentage; M ± SD = mean ± standard deviation; Birth order > 2 = subjects that had 2 or more younger siblings, ≤2 = subject either was first or second baby of parents; 1 = [OR = 2.4 (95%CI, 0.9–5.9) 0.054]; 2 = [OR = 5.8 (95%CI, 1.8–18.2) < 0.001]; 3 = [OR = 5.0 (95%CI, 1.4–17.5) P = 0.011]; 4 = [OR = 17.8 (95%CI, 4.2–74.5) P < 0.0001]; 5 = OR = 2.3 (95%CI, 1.1–4.7) P = 0.022; 6 = OR = 3.3 (95%CI, 1.5–7.2) P = 0.002.

* = No. of bidis and cigarettes smoked per day.

exposure and asthma becomes less strong after adolescence into adulthood, which may be because the child is spending less time at home.[21]

5.4. *Association between "birth order" and "asthma"*

In our study subjects, aged > 15 years, that had 2 or younger siblings were more likely to have risk for asthma. Likely to our result, a study observed children with older siblings were more likely than those without older siblings to have respiratory symptoms at age 4 years.[22] Contrast to our results, another study suggested first-born children in small sibships were more at risk than those in larger sibships.[23] However published studies were on children only and we observed significant association for age group > 15 years. Although the stability of these associations over time remains to be

determined, the patterns of asthma development may differ among low-income populations.[24]

5.5. *Association between "hospitalization of asthma" and "severity of asthma"*

Similar to our results, the study by Mitchell, suggested frequency or severity, or hospitalization, of asthma has increased so that asthmatics are more likely to have more severe attacks of asthma leading to more admissions to hospital.[25] However another study suggested that more mild cases also can be admitted.[26] However, factors which reflect an increase in severe asthma might be poor disease management and poverty[25,27] that are yet to be identified.

5.6. *Association between "maternal family history" and "severity of asthma"*

Likely to our result a meta-analysis found the OR for asthma in children of asthmatic mothers compared with non-asthmatic mothers was significantly increased at 3.04. The corresponding OR for asthma in children of asthmatic fathers was increased at 2.44. After comparisons, maternal asthma conferred greater risk of disease than did paternal asthma (3.04 vs 2.44, $P = 0.037$).[28] We did not association of family history of asthma with the severity of the disease for subjects aged > 15 years. The reason behind it could be that since asthma is a multi-factorial disease and many environmental factors also cause risk for disease asthma, while subjects aged > 15 years were remained in touch with active smoke as they were current smokers and in our study none of the subjects aged ≤ 15 years were smokers, might be the environmental risk factors affect more to subjects aged > 15 years as compared to subjects ≤ 15 years of age.

We also observed older age was responsible for the severity of asthma in age group > 15 years, similarly Lee et al (2000)[29] observed elderly asthmatics appear to have more severe asthma as evidenced by the increase in near-fatal episodes, and their increased clinical severity.

According to the modern climatic studies India has only three predominant seasons they are the summer months that end from about March to June, the rainy season makes longer from June to October and the winter season remains in India from November to March (MacDonald, 2011). In our study, maximum patients were recruited when the changes in seasons occur [July ($N = 29$), March ($N = 24$) and August ($N = 23$)], however we did not find association between seasonal variation and severity of disease asthma.

This study has some limitations that need to be acknowledged a) socio-economic status has not been calculated, b) Since the subjects of age group 1–50 years were included in the study, spirometry was not possible on all children, d) in this study; direct measurement of ambient air pollutants was not performed. The study was conducted on a large sample and covered all seasons in over 26 months. A stringent definition of asthma was used to avoid misclassification of other respiratory diseases. However data collection was done solely on information reported by parents and hence subject to interviewer and recall bias.

6. Conclusion

In conclusion, motor vehicle air pollution, industrial smoke, active and passive smoking, and exposure to ETS were observed to be associated with disease asthma as compared to non-asthmatics subjects. Factors, hospitalization for asthma and maternal family history of asthma and older age, were found to be associated with the severity of disease asthma. Since asthma is associated with motor vehicle air pollution, industrial smoke, active and passive smoking, and exposure to ETS, minimizing exposures to these may help in better asthma control. However this is an area specific study and further multi-center studies with long-term follow-ups are needed in this area to confirm this finding.

Conflicts of interest

All authors have none to declare.

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