Original Article

Prevalence and Risk Factors for Bronchial Asthma in Indian Adults: A Multicentre Study

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ABSTRACT

Background. There is limited information on field epidemiology of bronchial asthma in Indian adults.

Objectives. To estimate prevalence of bronchial asthma in different regions of India and to define risk factors influencing disease prevalence.

Methods. A field study was conducted at Chandigarh, Delhi, Kanpur and Bangalore through a two stage stratified (urban / rural) sampling and uniform methodology using a previously validated questionnaire. Asthma was diagnosed if the respondent answered affirmatively both to *(a)* whistling sound from chest, or chest tightness, or breathlessness in morning, and *(b)* having suffered from asthma, or having an attack of asthma in the past 12 months, or using bronchodilators. Besides demographic data, information on smoking habits, domestic cooking fuel used, atopic symptoms, and family history suggestive of asthma was also collected. Univariate and multivariate logistic regression modelling was performed to calculate odds ratio of various potential risk factors.

Results. Data from 73605 respondents (37682 men, 35923 women) were analysed. One or more respiratory symptoms were present in 4.3-10.5% subjects. Asthma was diagnosed in 2.28%, 1.69%, 2.05 and 3.47% respondents respectively at Chandigarh, Delhi, Kanpur and Bangalore, with overall prevalence of 2.38%. Female sex, advancing age, usual residence in urban area, lower socio-economic status, history suggestive of atopy, history of asthma in a first degree relative, and all forms of tobacco smoking were associated with significantly higher odds of having asthma.

Conclusion. Prevalence estimates of asthma in adults in this study, although lower than several previously reported figures, point to a high overall national burden of disease. **[Indian J Chest Dis Allied Sci 2006; 48: 13-22]**

Key words: Asthma, Epidemiology, Prevalence, Risk factors, Tobacco smoking.

INTRODUCTION

There is a noticeable increase in health care burden from asthma in several areas of the world. There is also a global concern on the change in asthma epidemiology and clinical spectrum. There is not only an apparent increase in general prevalence in several geographic areas, but also in the number of cases of difficult, refractory and fatal (or near fatal) asthma. Moreover, there are complex and confounding associations and relationships with infections and infestations, air pollution, tobacco smoking and environmental tobacco smoke exposure[1,2].

Data on prevalence of asthma is now available from several countries. Prevalence varies from region to region depending upon the definition used for diagnosis of asthma[3-12]. Current asthma is reported in 1.2 to 6.3% adults in most countries[3-7]. On the other hand, diagnosed asthma (*i.e.* asthma ever diagnosed by a clinician) in adults is generally reported as 2.7 to 4.0% in most European countries, 12.0% in England and 7.1% in the US[3,8-10]. In Australia, the prevalence is rather high (9.5 to 17.9%)[4,6]. Tristan da Cunha is an unique example where more than half the population (56%) is reported to suffer from asthma, supporting a strong genetic link[11].

There is very limited data on asthma epidemiology from the developing world, including India. The overall burden of asthma in India is estimated at more than 15 million patients[13]. However, India is a vast country with immense geographical, economical, racial, religious and socio-political diversity. There are obvious differences in prevalence of disease and approach to management of health problems. It is an enormously difficult and costly proposition to collect national statistics on diagnosis and management of common diseases, as it requires coordination and cooperation between several centres

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spread across the country. Although some attempts have been made in the past, they suffer from several scientific drawbacks, the principle being a lack of uniformity of methodology and analysis of data.

There are only a few studies from India on field epidemiology of asthma. In a study conducted more than 30 years ago, prevalence of asthma was reported as 2.78% in an urban population aged 30-49 years[14]. It was also reported in the same study that the prevalence in morbidity surveys of Government employees and their families in Delhi was 1.8%. These rates are unlikely to represent the current prevalence. Unpublished figures, from 1.5% to 15% or higher, have been quoted from time to time. Most of these assumptions do not reflect general prevalence. They also suffer from several other drawbacks such as *(a)* the lack of uniform definition of asthma, *(b)* inappropriate and / or non-standardised methodology, *(c)* inadequate sample size, *(d)* demographic variations in different populations and samples, and *(e)* inadequate or inappropriate analytic techniques.

Data from a few population based studies in adults has recently become available. In a study from Mumbai, conducted as part of the European Community Respiratory Health Survey, asthma prevalence in adults aged 20-44 years was reported to be 3.5% using 'clinician diagnosis' and 17% using a very broad definition (which included prior physician diagnosis and/or a positive bronchoprovocation test)[15]. Prevalence was similar in men (3.8%) and women (3.4%). We have earlier reported data on prevalence of asthma in Chandigarh using a field questionnaire[16]. In a survey of more than 2000 individuals, asthma prevalence was 2.0% in women and about 3.65% in men. In addition, the first phase of the International Study of Asthma and Allergies in Childhood (ISAAC) has provided data on asthma prevalence in 6-7 and 13-14 year old Indian children[17]. Little information is available on other issues and the variables affecting asthma epidemiology in this country.

While defining population characteristics through large population surveys, one needs a simple operational definition of asthma that is understood by field workers with little or no clinical background, and involves minimal use of laboratory investigations. We have adapted a questionnaire to assist in field diagnosis of asthma for epidemiological purposes and have estimated prevalence of disease in the local population, both in children and adults[16]. The same methodology was extended to other areas in the country in an effort to arrive at a general estimate of national burden and to define regional differences in factors influencing prevalence of asthma in adults.

MATERIAL AND METHODS

Prevalence of asthma in adults was studied in different parts of the country with a multicentric design using uniform methodology. The essential components of this study design were *(a)* a single definition of asthma developed prior to initiation of data collection, *(b)* a standardized and validated study questionnaire developed at the Central Coordinating Centre, with provision for translation into local languages, *(c)* uniform methods of data collection at each participating centre, and *(d)* centralised data analysis. The four participating centres were located at Chandigarh, Delhi, Kanpur and Bangalore. The coordinating centre was located at Chandigarh.

Questionnaire Development

The questionnaire envisaged for use in this study had two components. The first part of the questionnaire was aimed at collecting information on respiratory symptoms and establishing a diagnosis of asthma based on this data. The second component was aimed at collecting information on possible demographic and environmental exposure factors influencing the prevalence of asthma.

A Hindi translation of the International Union Against Tuberculosis and Lung Diseases (IUATLD) respiratory symptoms questionnaire was used for the first component[18]. This translation has been previously standardized and validated for diagnosing asthma under field conditions in adults, and details on this methodology are available in an earlier publication[16]. In brief, the original questionnaire (in English) was translated to Hindi. Reliability of the translated version was established using test- retest and split half methods on 200 individuals. The questionnaire was then administered to 506 patients attending Chest Clinic, and a final diagnosis (asthma or no asthma) was reached by the clinician in all instances using clinical information and appropriate investigations. Each individual item in the questionnaire was tested for its sensitivity and specificity in diagnosing asthma using physician diagnosis as gold standard. Questions with a high sensitivity and those with a high specificity were then selected to frame a composite questionnaire definition of asthma. The questionnaire definition was then validated in field conditions on 753 individuals, using physician diagnosis as the gold standard. Investigators from all centres decided by consensus to maintain the structure of this Hindi questionnaire and agreed to use the definition of asthma from this questionnaire.

Important risk factors for asthma for which information could be gathered through a questionnaire under field conditions were identified through consensus by investigators at each centre, and supplemented with suggestions from the Indian Council of Medical Research Asthma Task Force. The language of questions, and categorization of responses, were agreed upon through consensus.

The Hindi questionnaire was used at Chandigarh, Delhi and Kanpur. A Kannada translation was carried

out for use at Bangalore. A comprehensive Project Manual was prepared for use by investigators and field staff, which included detailed instructions for filling out responses to each item of the questionnaire, as well as operational details on data entry.

Sampling Technique

The sample design at each of the participating centres was a two stage stratified (urban / rural) sampling, where villages / urban localities formed the first stage units and households formed the second stage units. Both the urban and rural units were confined to municipal limits.

In the urban setting, the locations where the survey was carried out were decided by a random selection of a number of areas defined by boundaries of municipal wards or census blocks or city sectors as appropriate. In the rural setting, the sample area was identified using community development block as a unit. Villages were selected at random from among all villages in the block. Field workers approached the village sarpanch or other community leaders to enlist their cooperation and help in defining the boundary of the area in which the survey was to be carried out. With their help, a rough map of the village was drawn and the number of households identified in different areas. Approximately 500 households were targeted in each village / urban cluster. In case the villages were small, two or more neighbouring villages were combined till the group had approximately 500 households. In case the village was substantially large, it was partitioned into two or more areas, each with approximately 500 households.

Since inhabitants in a given locality could be living in separate areas defined on the basis of caste, sect or religion, each selected urban or rural cluster was roughly divided into four segments based on geographical or notional landmarks (*e.g.* north, south, east and west), and a quarter of the sample covered in each segment. For this purpose, help was obtained from persons knowledgeable about the area. This ensured that all groups of people residing in the locality were represented in the sample covered. The household in a particular segment from where the survey was to be started was then randomly selected by using random number tables to pick a number between the first and last numbers of the houses. Interview started in the selected household and the field worker then moved on the the next nearest house. The process continued till the required number of individuals had been interviewed in that particular area. Field workers carried out 1000 interviews in each cluster (with 250 interviews in each segment). Once the field worker reached the target sample in any segment, all adults in this last household were interviewed.

A household was defined as a person or a group of persons who commonly lived together and took meals from a common kitchen unless exigencies of work prevented them from doing so. There could be households of persons related by blood or a household of unrelated persons or a mix of both. Collective living arrangements such as boarding houses, hotels, messes, jails, army camps, boarding schools, ashrams, (etc.) were not considered households and were not included in the survey. The head of the household was designated the person acknowledged as such by members of household, and was the person who made important decisions for the household and was responsible for its upkeep and maintenance.

Questionnaire Administration

In each of these clusters, field workers carried out interviews of all adult members in each household, moving to the next selected group once the previous one was exhausted, and continued till the requisite sample had been covered. In each household, the field worker interviewed all adults aged 15 years or more. Interviews were conducted face to face in privacy and in homes of the respondent. In case it was acceptable to the respondent, some interviews were conducted outside the house in a centralized area like the village *chaupal*, or a school, to ensure privacy. In case a household was locked or a respondent was not available, the field worker noted it as such, and returned at a subsequent date at a time convenient to the respondent to fill the questionnaire. If three such attempts at meeting residents of a household were unsuccessful, the household was dropped from the list.

All field workers read and understood the questionnaire thoroughly to know the language and meaning of each question. They also went through the detailed project manual carefully before going to the field to understand how the interview was to be conducted, questions asked and responses recorded and coded. To ensure that the quality of data collected was uniform, all field workers were instructed to follow all instructions carefully and exactly, so that methodology used by all interviewers was indentical. A separate questionnaire form was completed for each respondent in a household. Questions were asked exactly in the sequence in which they were printed in the questionnaire. Each question was read aloud exactly as written, without altering the wording. If the question was not understood, the interviewer could use additional explanations or examples provided in instructions for individual questions in the project manual. If no additional instructions were provided in the manual, the question was repeated in its original form, without probing for an answer. If, even after a brief explanation, doubt remained as to whether the answer is 'Yes' or 'No' , the answer was recorded as 'No'. However, interviewers could listen to additional comments from the respondents as this helped in improving rapport with the respondent.

A field supervisor at each participating centre

collected the list of all households visited by the field workers, and later made a visit to ten percent randomly selected households to verify if the interview was actually conducted. He/she also administered the questionnaire again to randomly selected respondents to check for any mistakes made by the interviewer.

Data Analysis and Statistical Methods

A computer programme was specifically written for this project using the software EpiInfo (version 6). This software, along with the required data entry files, was installed on a computer at each participating centre for independent data entry. These separate databases generated at each centre were later merged together to create a total database. All data were transferred to SPSS (version 10.0) software (SPSS Inc., Chicago, IL) for further analysis. Asthma was diagnosed if the respondent answered affirmatively both to *(a)* wheezing or whistling sound from chest, or chest tightness or breathlessness in morning, and *(b)* having suffered from asthma, or having an attack of asthma in past 12 months, or using inhaled or oral bronchodilators. Prevalence of asthma was calculated as the number of subjects categorised as having asthma (based on the definition described above) divided by the total number of subjects in that particular group.

For purpose of descriptive analysis, gender and 'current' residence were used to create subgroups at each centre separately, as well as for the entire study population. Univariate logistic regression analysis was conducted to calculate odds ratio to determine the relationship between each potential risk factor studied and presence of asthma. Such analysis was conducted for each centre individually, as well as for the entire study population. Potential risk factors to be studied were categorised based on the information available from the questionnaire. Influence of type of residence was studied using categories based on 'usual residence' rather than 'current residence'. Atopy was defined as the presence of either recurrent skin rash, or recurrent episodes of sneezing or coryza, or itchiness in eyes. Analysis on items related to environmental tobacco smoke (ETS) exposure was restricted only to subjects who were nonsmokers. Multivariate logistic regression modelling was also performed to assess odds ratio for each potential risk factor after adjusting for others.

RESULTS

Data from a total of 73605 respondents were included in the final analysis. There were 37682 (52%) men and 35923 (48%) women. While about half of the subjects were aged between 15 and 34 years, approximately 10 percent individuals were aged 65 years or more at each centre (Table 1). The distributions based on occupation, education and socio-economic status were variable at each centre (Table 1).

The proportion of subjects who admitted to have ever smoked in the past were variable at the four centres and between men and women. In general, 1% or fewer women in urban areas had ever smoked tobacco in the past; figures for rural women were higher (Table 2). About 25-40% men in rural areas and 20–30% men in urban areas had ever smoked tobacco in the past (Table 2). Cigarette and *bidi* were the commonest forms of smoked tobacco, and only a small minority of smokers had quit smoking in the past (Table 2). Approximately 40% of subjects studied were regularly involved in cooking food at home; the vast majority of these subjects were women. Liquefied petroleum gas (LPG) was the commonest cooking fuel used at all urban areas and rural Delhi; in other rural areas, solid fuels (*e.g.* wood, dung, etc.) were more commonly used (Table 2).

One or more respiratory symptoms were present in 4.3 to 10.5% of subjects (Table 3). Symptoms were higher amongst Kanpur and Bangalore subjects. Wheezing was least prevalent in Delhi and most prevalent at Bangalore. Chest tightness following exposure to dust was reported by more than 8% respondents in urban Kanpur, much higher than other areas studied. Atopy (skin rash, rhinorrhoea or itchiness in eyes) was present in about 2.8 to 11.1% individuals, and was most common at Chandigarh (Table 3). Prevalence of a family history of atopy or of asthma in the first-degree relatives was variable, with highest figures at Chandigarh, followed by Bangalore (Table 3).

As per the definition used in the survey, asthma was present in 2.28%, 1.69%, 2.05 and 3.47% respondents respectively at Chandigarh, Delhi, Kanpur and Bangalore, with an overall prevalence of 2.38%. Prevalence was relatively higher among female respondents of urban areas at Delhi, Chandigarh and Bangalore (Table 4). The prevalence in the two sexes was similar in Kanpur. Based on the place of current residence, urban people had greater prevalence at Chandigarh, Delhi and Kanpur while the prevalence was similar at Bangalore (Table 4).

On univariate analysis, female sex was identified as a significant risk factor for asthma only at Chandigarh and Bangalore (Table 5). Subjects 'usually residing' in urban areas had a higher prevalence of asthma at Chandigarh, Delhi and Kanpur, and a lower prevalence at Bangalore; in isolation, these differences were significant only at Chandigarh and Delhi (Table 5). In univariate analysis, increasing age was identified with progressively increasing odds of having asthma at all centres (Table 5). High socio-economic status was identified as a significant risk factor for asthma at Chandigarh and Kanpur (Table 5). The odds of having asthma in atopic individuals, as well as those with a family history of asthma, were significantly high at all centres (Table 5). Ever-smokers had significantly higher odds of having asthma at all centres. Among smokers, prevalence of asthma was higher for all tobacco products (cigarettes, *bidi*s and *hookah*) as compared to

Table 1. Demographic profile of the study population based on current residence at each centre

	Chandigarh		Delhi		Kanpur		Bangalore	
	Rural (N=10309)	Urban (N=11355)	Rural (N=7682)	Urban (N=7960)	Rural (N=7199)	Urban (N= 11659)	Rural (N= 8114)	Urban (N= 9327)
Gender								
Men	5333 (51.7)	5717 (50.3)	3933 (51.2)	4033 (50.7)	3921 (54.5)	6107 (52.4)	4111 (50.7)	4527 (48.5)
Women	4976 (48.3)	5638 (49.7)	3749 (48.8)	3927 (49.3)	3278 (45.5)	5552 (7.6)	4003 (49.3)	4800 (51.5)
Age								
15-24 years	2925 (28.4)	3162 (27.8)	1484 (19.3)	1691 (21.2)	2411 (33.5)	3610 (31.0)	2242 (27.6)	2821 (30.2)
25-34 years	2676 (26.0)	2402 (21.2)	2176 (28.3)	1997 (25.1)	1550 (21.5)	2611 (22.4)	1789 (22.0)	2763 (29.6)
35-44 years	1771 (17.2)	2112 (18.6)	1565 (20.4)	1562 (19.6)	1205 (16.7)	2244 (19.2)	1480 (18.2)	1783 (19.1)
45-54 years	1149 (11.1)	2143 (18.9)	1072 (14.0)	1229 (15.4)	848 (11.8)	1565 (13.4)	1116 (13.8)	1047 (11.2)
55-64 years	822 (8.0)	852 (7.5)	752 (9.8)	842 (10.6)	664 (9.2)	941 (8.1)	685 (8.4)	562 (6.0)
65-74 years	665 (6.5)	493 (4.3)	428 (5.6)	448 (5.6)	381 (5.3)	530 (4.5)	524 (6.5)	269 (2.9)
>=75 years	301 (2.9)	191 (1.7)	205 (2.7)	191 (2.4)	140 (1.9)	158 (1.4)	278 (3.4)	82 (0.9)
Occupation								
Unemployed / retired	2156 (20.9)	3002 (26.4)	1586 (20.6)	1920 (24.1)	1489 (20.7)	3063 (26.3)	1429 (17.6)	1476 (15.8)
Household work only	3928 (38.1)	3335 (29.4)	2927 (38.1)	2570 (32.3)	2649 (36.8)	3841 (32.9)	1821 (22.4)	2759 (29.6)
Unskilled labourer	1278 (12.4)	368 (3.2)	450 (5.9)	557 (7.0)	652 (9.1)	557 (4.8)	1326 (16.3)	1309 (14.0)
Skilled labourer	113 (1.1)	67 (0.6)	263 (3.4)	205 (2.6)	173 (2.4)	588 (5.0)	346 (4.3)	692 (7.4)
Business	867 (8.4)	890 (7.8)	913 (11.9)	1220 (15.3)	347 (4.8)	1484 (12.7)	407 (5.0)	724 (7.8)
Agriculturist	1037 (10.1)	8 (0.1)	269 (3.5)	4 (0.1)	1479 (20.5)	52 (0.4)	2265 (27.9)	10 (0.1)
Worker (Govt./Private)	685 (6.6)	1713 (15.1)	1155 (15.0)	1301 (16.3)	382 (5.3)	1953 (16.8)	489 (6.0)	2020 (21.7)
Supervisor (Govt./Pvt.)	209 (2.0)	1377 (12.1)	66 (0.9)	34 (0.4)	27 (0.4)	72 (0.6)	25 (0.3)	236 (2.5)
Officer (Govt./Private)	36 (0.3)	595 (5.2)	53 (0.7)	149 (1.9)	1 (0.0)	49 (0.4)	6 (0.1)	101 (1.1)
Education								
Illiterate	3122 (30.3)	1111 (9.8)	1967 (25.6)	1242 (15.6)	2260 (31.4)	2592 (22.2)	3396 (41.9)	1842 (19.7)
1-5 years	1219 (11.8)	606 (5.3)	569 (7.4)	500 (6.3)	934 (13.0)	1103 (9.5)	962 (11.9)	985 (10.6)
6-10 years	4203 (40.8)	2965 (26.1)	2745 (35.7)	2256 (28.3)	2944 (40.9)	4140 (35.5)	2961 (36.5)	4266 (45.7)
11-15 years	1584 (15.4)	4687 (41.2)	2089 (27.2)	3098 (38.9)	908 (12.6)	2912 (25.0)	735 (9.1)	1843 (19.8)
>15 years	181 (1.8)	1986 (17.5)	312 (4.1)	863 (10.8)	153 (2.1)	912 (7.8)	60 (0.7)	391 (4.2)
Socio-economic status								
Low	1327 (12.9)	861 (7.6)	1808 (23.5)	3128 (39.3)	6020 (83.6)	7327 (62.8)	2254 (27.8)	2864 (30.7)
Medium	8867 (86.0)	8863 (78.1)	4975 (64.8)	4062 (51.0)	1163 (16.2)	3969 (34.0)	5284 (65.1)	5471 (58.7)
High	115 (1.1)	1631 (14.4)	899 (11.7)	770 (9.7)	16 (0.2)	363 (3.1)	576 (7.1)	992 (10.6)

Figures in parentheses are percentages.

Table 2. Smoking and cooking habits in the study population

	Chandigarh		Delhi		Kanpur		Bangalore	
	Rural (N=10309)	Urban (N=11355)	Rural (N=7682)	Urban (N=7960)	Rural (N=7199)	Urban (N=11659)	Rural (N=8114)	Urban (N=9327)
Ever smoker	2434 (23.6)	1198 (10.6)	1909 (24.9)	762 (9.6)	1084 (15.1)	1206 (10.3)	1427 (17.6)	1476 (15.8)
• *Tobacco product*								
- Cigarette	310 (3.0)	622 (5.5)	215 (2.8)	278 (3.5)	67 (0.9)	476 (4.1)	265 (3.3)	828 (8.9)
- *Bidi*	1968 (19.1)	557 (4.9)	1433 (18.7)	469 (5.9)	1005 (14.0)	728 (6.2)	1162 (14.3)	648 (6.9)
- *Hookah*	156 (1.5)	18 (0.2)	260 (3.4)	14 (0.2)	8 (0.1)	2 (0.0)	-	-
- Others	-	1 (0.0)	1 (0.0)	1 (0.0)	4 (0.1)	-	-	-
• *Current status*								
- Current smoker	2237 (21.7)	1011 (8.9)	1790 (23.3)	707 (8.9)	1025 (14.2)	1085 (9.3)	1260 (15.5)	1300 (13.9)
- Left < 1 year back	30 (0.3)	23 (0.2)	25 (0.3)	10 (0.1)	10 (0.1)	25 (0.2)	10 (0.1)	20 (0.2)
- Left > 1 year back	167 (1.6)	164 (1.4)	94 (1.2)	45 (0.6)	49 (0.7)	96 (0.8)	157 (1.9)	156 (1.7)
Regular cooking	3784 (36.7)	4526 (39.9)	3146 (41.0)	3010 (37.8)	2577 (35.8)	4469 (38.3)	3074 (37.9)	3852 (41.3)
• *Cooking fuel*								
- Kerosene	67 (0.6)	246 (2.2)	64 (0.8)	143 (1.8)	7 (0.1)	282 (2.4)	69 (0.9)	1332 (14.3)
- Solid fuel	2495 (24.2)	146 (1.3)	272 (3.5)	33 (0.4)	2372 (32.9)	633 (5.4)	2637 (32.5)	346 (3.7)
- LPG (Liquefied petroleum gas)	1222 (11.9)	4134 (36.4)	2810 (36.6)	2834 (35.6)	198 (2.8)	3554 (30.5)	368 (4.5)	2174 (23.3)

Figures in parentheses are percentages.

Table 3. Prevalence of self reported respiratory symptoms over the preceding twelve months (as listed in the study questionnaire), history suggestive of atopic manifestations, and family history of asthma in the study population

	Chandigarh		Delhi		Kanpur		Bangalore	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Respiratory symptoms								
Wheezing	2.5%	2.5%	2.1%	2.1%	3.1%	2.8%	4.8%	4.3%
Morning tightness / breathlessness	2.3%	2.5%	2.7%	2.5%	2.4%	2.7%	3.5%	3.3%
Breathlessness on exertion	3.6%	3.4%	5.9%	5.3%	7.2%	8.0%	7.4%	6.2%
Breathlessness without exertion	2.9%	2.0%	2.7%	2.6%	2.3%	2.5%	1.8%	1.2%
Breathlessness at night	2.1%	2.0%	2.4%	2.5%	1.9%	2.4%	3.1%	2.4%
Cough at night	2.4%	1.7%	2.9%	2.0%	2.9%	3.1%	5.6%	5.4%
Cough in morning	2.4%	1.8%	2.9%	2.3%	4.1%	3.7%	4.4%	4.4%
Phlegm in morning	1.9%	2.0%	2.7%	2.0%	3.2%	3.1%	4.4%	4.4%
Breathlessness (usual or forever)	2.5%	3.0%	4.4%	3.6%	5.3%	4.3%	4.4%	3.8%
Chest tightness on dust exposure	2.1%	3.2%	3.2%	3.5%	3.3%	8.1%	3.6%	4.5%
Dyspnoea on dust exposure	2.1%	3.0%	3.9%	3.8%	3.4%	7.8%	4.9%	5.8%
Ever diagnosed to have asthma	2.1%	2.9%	0.8%	1.9%	1.6%	1.4%	3.9%	3.8%
Attack of asthma	0.6%	1.3%	0.4%	0.8%	0.9%	0.6%	3.3%	3.1%
Inhaler use	1.7%	2.7%	1.4%	1.9%	1.5%	2.2%	2.6%	2.6%
Any of the above	4.3%	4.7%	6.7%	5.9%	8.7%	9.8%	10.5%	10.3%
Atopic manifestations								
Recurrent skin rashes	3.5%	3.9%	2.2%	1.4%	0.3%	0.7%	1.5%	1.9%
Recurrent coryza	3.7%	7.6%	2.0%	1.4%	3.4%	4.4%	1.8%	3.3%
Recurrent eye itchiness	2.9%	5.3%	2.3%	0.4%	2.3%	4.4%	4.7%	3.5%
Any of the above	6.9%	11.1%	4.6%	2.8%	4.6%	7.3%	6.7%	6.8%
First degree relative with asthma	14.6%	13.6%	4.4%	9.1%	3.1%	2.1%	9.8%	11.6%

Table 4. Overall prevalence of asthma at various centres

	Gender	Rural	Urban	Total
Chandigarh	Men	1.89%	2.24%	2.07%
	Women	2.09%	2.87%	2.51%
	Total	1.99%	2.55%	2.28%
Delhi	Men	1.42%	1.66%	1.54%
	Women	1.23%	2.42%	1.84%
	Total	1.33%	2.04%	1.69%
Kanpur	Men	1.81%	2.19%	2.04%
	Women	1.83%	2.20%	2.06%
	Total	1.82%	2.20%	2.05%
Bangalore	Men	3.36%	3.03%	3.18%
	Women	3.72%	3.77%	3.75%
	Total	3.54%	3.41%	3.47%
Total	**Men**	**2.12%**	**2.29%**	**2.21%**
	Women	**2.24%**	**2.81%**	**2.56%**
	Total	**2.18%**	**2.55%**	**2.38%**

subjects who had never smoked (Table 5). Between *bidi*s and cigarettes, the odds of having asthma were higher for cigarettes at Chandigarh and Delhi, and higher for *bidi*s at Kanpur and Bangolore. In univariate analysis, persons regularly cooking had significantly higher odds of having asthma only at Kanpur. However, use of LPG for cooking appeared to have an overall protective effect (Table 5).

Multiple logistic regression analysis carried out to assess odds ratio of various potential risk factors (gender, age, usual residence, socio-economic status, history of atopy, family history of asthma, tobacco smoking and cooking habits) after adjustment for each other, and for between – centre differences (Table 6). After adjusting for all other potential risk factors, Bangalore had a significantly higher prevalence of asthma as compared to Chandigarh. Overall, female sex, advancing age, usual residence in urban area, history suggestive of atopy, history of asthma in a first degree relative, and all forms of tobacco smoking were

Table 5. Crude odds ratio (with 95% confidence intervals) of individual risk factors influencing prevalence of asthma at each centre

	Chandigarh	Delhi	Kanpur	Bangalore
Gender				
Female*	1.000	1.000	1.000	1.000
Male	0.823 (0.689-0.984)	0.838 (0.657-1.069)	0.992 (0.811-1.213)	0.844 (0.717-0.994)
Age				
15-24 years*	1.000	1.000	1.000	1.000
25-34 years	1.523 (1.010-2.296)	1.942 (0.966-3.907)	1.920 (1.173-3.142)	1.742 (1.242-2.443)
35-44 years	2.937 (2.005-4.303)	3.442 (1.753-6.759)	3.982 (2.546-6.227)	3.532 (2.568-4.857)
45-54 years	6.146 (4.319-8.746)	6.646 (3.460-12.764)	6.677 (4.308-10.349)	4.928 (3.563-6.816)
55-64 years	6.326 (4.282-9.344)	12.219 (6.432-23.216)	12.117 (7.881-18.630)	7.456 (5.330-10.431)
65-74 years	12.849 (8.850-18.656)	15.930 (8.216-30.888)	18.644 (11.988-28.996)	10.031 (7.066-14.240)
>= 75 years	10.236 (6.387-16.406)	19.369 (9.455-39.680)	21.323 (12.395-36.682)	14.085 (9.441-21.016)
Usual residence				
Rural*	1.000	1.000	1.000	1.000
Urban	1.247 (1.043-1.492)	1.432 (1.115-1.839)	1.182 (0.950-1.470)	0.935 (0.788-1.109)
Mixed	0.764 (0.188-3.108)	1.194 (0.375-3.799)	0.040 (0.000-2.2x10^{13})	1.221 (0.900-1.656)
Socio-economic status				
Low*	1.000	1.000	1.000	1.000
Middle	0.924 (0.686-1.245)	1.066 (0.811-1.401)	1.232 (0.987-1.539)	0.859 (0.719-1.027)
High	1.786 (1.235-2.582)	1.164 (0.765-1.769)	3.255 (2.079-5.097)	0.935 (0.691-1.266)
Atopy				
History not suggestive of atopy*	1.000	1.000	1.000	1.000
History suggestive of atopy	18.326 (15.192-22.106)	15.547 (11.861-20.380)	29.097 (23.480-36.058)	9.944 (8.329-11.872)
Family history of asthma				
No first degree relative with asthma*	1.000	1.000	1.000	1.000
First degree relative with asthma	4.137 (3.366-5.085)	7.179 (5.292-9.738)	9.223 (6.558-12.970)	7.408 (6.258-8.770)
Usual smoking habit				
Nonsmoker*	1.000	1.000	1.000	1.000
Cigarette smoker	2.540 (1.843-3.501)	2.988 (1.866-4.785)	1.641 (0.985-2.733)	1.515 (1.123-20.42)
Bidi smoker	1.742 (1.366-2.223)	2.104 (1.550-2.857)	2.207 (1.688-2.885)	2.025 (1.632-2.511)
Smoker of *hookah* / other products	7.757 (4.940-12.182)	2.109 (1.028-4.326)	9.007 (2.007-40.419)	-
Usual cooking habit				
No self cooking*	1.000	1.000	1.000	1.000
Cooking with liquefied petroleum gas (LPG)	1.043 (0.851-1.278)	0.853 (0.658-1.105)	0.721 (0.549-0.946)	0.849 (0.662-1.090)
Cooking with kerosene	0.260 (0.065-1.047)	0.264 (0.037-1.875)	0.011 (0.000-11.900)	0.985 (0.728-1.334)
Cooking with solid fuel	0.542 (0.381-0.770)	0.355 (0.088-1.349)	0.552 (0.395-0.770)	1.002 (0.804-1.248)

*: Reference category.

Table 6. Multiple logistic regression modelling to assess potential risk factors for asthma in the entire study population, after adjusting for 'between centre' differences

	OR(95%CI)
Location	
Chandigarh	1.000
Delhi	1.026 (0.870-1.211)
Kanpur	1.153 (0.978-1.359)
Bangalore	1.707 (1.483-1.965)
Gender	
Male*	1.000
Female	1.435 (1.230-1.675)
Age	
15-24 years *	1.000
25-34 years	1.618 (1.289-2.031)
35-44 years	2.819 (2.273-3.496)
45-54 years	4.838 (3.920-5.973)
55-64 years	7.504 (6.037-9.328)
65-74 years	11.332 (9.043-14.202)
>= 75 years	13.472 (10.247-17.711)
Usual residence	
Rural*	1.000
Urban	1.342 (1.190-1.514)
Mixed	1.282 (0.928-1.771)
Socio-economic status	
Low*	1.000
Middle	0.831 (0.730-0.944)
High	0.717 (0.582-0.883)
Atopy	
History not suggestive of atopy*	1.000
History suggestive of atopy	12.304 (11.057-13.691)
Family history of asthma	
No first degree relative with asthma*	1.000
First degree relative with asthma	6.104 (5.365-6.946)
Usual smoking habit	
Nonsmoker*	1.000
Cigarette smoker	1.534 (1.231-1.910)
Bidi smoker	1.599 (1.357-1.883)
Smoker of *hookah* / other products	2.227 (1.481-3.350)
Usual cooking habit	
No self cooking *	1.000
Cooking with liquefied petroleum gas	0.853 (0.715-1.017)
Cooking with kerosene	0.869 (0.623-1.214)
Cooking with solid fuel	1.035 (0.840-1.276)

*: Reference category; Results are presented as odds ratio (OR), with 95% confidence intervals (95% CI) in parentheses.

associated with higher odds of having asthma. Better socio-economic status had significantly lower odds of having asthma.

DISCUSSION

In the clinical setting, asthma is diagnosed based on history, physical examination, and physiological testing (which most commonly includes, but is not limited to, spirometry and bronchodilator reversibility testing). In population based surveys, time and logistic constraints do not allow the use of most of these modalities. Although the use of a validated questionnaire remains the most popular method for field studies, there can be no strict validation for any test of asthma. Epidemiological studies on prevalence of asthma, therefore, often suffer from a lack of definite criteria for diagnosis of disease and a standardised methodology[19]. Different investigators have used different parameters such as physician-diagnosed asthma, demonstration of variable airflow obstruction, or bronchial hyperreactivity as gold standards for validating questionnaires employed to diagnose asthma under field conditions. Each method has its own limitations of either under-diagnosing or over-diagnosing asthma.

A significant proportion of the general population suffers from respiratory symptoms of varied etiology (including asthma), and the greatest problems in any population survey is to correctly identify asthmatics from this subset. Obviously, no epidemiological tool can be a perfect discriminator in this regard with 100% sensitivity and specificity. The problem of misdiagnosis in questionnaire-based surveys depends not only on the structure and inherent properties of the questionnaire, but also on the social, demographic and medical factors of the population being studied. Any epidemiological study can therefore provide only imprecise estimates of the true burden of disease, although use of better tools can certainly reduce the degree of imprecision. We used a questionnaire validated against physician-diagnosed asthma under both hospital and field conditions[16].

There is very limited information on prevalence of asthma among adults in India. Nevertheless, our estimates are close to the figure of 2.78% reported three decades ago in a middle-aged urban population[14]. These results are also similar to the asthma prevalence (3.5%) reported in Mumbai more recently using a 'clinician diagnosis' based on the European Community Respiratory Health Survey protocol[15]. As stressed earlier, the largest obstacle in comparing prevalence estimates across two or more fields studies relates to methodological differences in study design, disease definition, and data analysis.

The biggest challenge in any epidemiological study aiming at prevalence estimation is the choice of definition of disease. Based on the need, setting, and available resources, investigators have used different definitions of asthma in the past. This partly accounts for the high variability in prevalence estimates reported earlier. A loose definition is likely to include several false-positives in the prevalence figure, while a very comprehensive definition may miss several true asthmatics. In this study, we have employed a definition that incorporated a set of questions with high sensitivity, and another with high specificity. In a recent study from Mumbai, asthma prevalence was calculated as 3.5% by physician diagnosis, and as 17% using a very broad definition including those with asymptomatic bronchial hyperreactivity[15]. This emphasizes the fact that prevalence figures may change dramatically with change in the disease definition. The obvious problem with a relatively soft definition is that a lot of other cardio-respiratory conditions may produce wheezing. In particular, chronic obstructive pulmonary disease and asthma cannot be differentiated based on this single symptom, and hence such a definition tends to over-diagnose asthma and artificially inflate prevalence estimates. The other common definition used in several surveys in the West is that of a prior physician-diagnosis of asthma. The problem with this definition is that of physician-misdiagnosis. A lot of patients of chronic obstructive pulmonary disease, as well as those having dyspnoea due an unrecognized cause, are labelled as asthmatics by physicians. On the other hand, a lot of patients do not disclose this diagnosis to the interviewer at time of questionnaire administration due to the stigma attached with this disease. Thus, this definition yields both false positives and false negatives. The overall prevalence of any respiratory symptom varied from 3-11% across different centres and place of residence. As the definition of asthma is broadened, prevalence estimates would ultimately tend to reach these figures, but only a minority of these individuals will have true asthma.

Prima facie, the prevalence figures reported in this study may appear to be lower than the generally quoted figures in the lay press. However, most such impressions are based on observations in hospitals or Chest Clinics, or in other select populations, with a very heavy bias towards inclusion of symptomatic individuals. The population prevalence is an assessment of the problem from an entirely different perspective. In fact, a population prevalence of 2.38% is a very high figure from the national view point in calculating disease burden. Even with most rough estimates, in a population of over 100 crores, about 2.38 crore individuals (including children) are likely to suffer from asthma. Further, asthma is a life long disease. The morbidity in terms of absence from school and work, hospitalizations and Emergency Room visits is very high. The economic burden of management of asthma is likely to be huge both for the patient's family as well as for the State. It is also noteworthy that asthma

prevalence figures reported from several Asian countries are largely similar to those reported in this study. For instance, asthma prevalence in Singapore, Malaysia, Nepal, China, Pakistan and Bangladesh is estimated between 1-5%[20]. These figures do imply a relatively lower prevalence of asthma in adults in Asia as compared to their Western counterparts. Even in Europe and USA, Asian immigrants tend to have lower asthma prevalence figures than their native western counterparts. It is not clear whether genetic or environmental factors are responsible for these differences.

The study also provides us with valuable information on population prevalence of respiratory symptoms, atopy and asthma. More importantly, it gives us an insight into relationships of respiratory symptoms, atopy and asthma with several independent and causal factors which include the anthropometric and exposure variables. In particular, the relationship of personal smoking, passive exposures to tobacco smoke and to combustion of domestic cooking fuels have significant clinical importance. Although there is a general perception that exposure to biomass fuels may be a risk factor for asthma, the same is not borne out by our findings.

Approximately one third to one half of asthma cases in population-based studies are attributable to atopy[21]. These figures may be still higher for patients with severe disease[22]. The recently concluded European Community Respiratory Health Survey (ECRHS) was the first international multicentre study in adults using a common standard protocol measuring atopy and asthma in the same time period. In this study, the effect of atopy on the prevalence of asthma varied widely between centres, probably because of variations in factors related to the expression of asthma and to the prevalence of sensitisation, particularly to house dust mite[23]. The overall attributable fraction of asthma symptoms caused by atopy in this study was 30%, but increased to 45% with a physician diagnosis of asthma, and varied widely between centres. A positive relationship between asthma in family members and development of airway hyperresponsiveness and / or asthma in an individual is well recognised[24,25]. Odds ratios for a first-degree relative with asthma have ranged from 1.5 to 10 in several studies on childhood asthma[26]. We have also found that history of asthma in a first degree relative is an independent risk factor for asthma. In fact, the adjusted odds of having asthma with such a history were very high, second only to a history suggestive of atopy (Table 6). This may point to an underlying hereditary basis for asthma. Even though a pure genetic basis of asthma appears unlikely, several chromosomal regions and loci showing linkage to, and association with, airway inflammation, asthma and asthma-linked phenotypes have recently been identified[27, 28].

A particularly interesting observation from our data is the importance of tobacco smoking in relationship to prevalence of asthma. Data in this regard is rather sparse, as several large scale questionnaire based surveys on asthma prevalence tend to exclude smokers. Even in those reports where the issue of tobacco smoking has been specifically addressed, the results are highly variable. In a cross-sectional survey of more than 8,000 subjects aged 23 years, active smoking was observed to have an association with bronchial asthma[29]. Another prospective, community-based study of Danish school children also reported that active smoking was an independent risk factor for the development of asthma-like symptoms[30]. In contrast, other investigators have failed to demonstrate a significant association between tobacco smoking and asthma[31,32]. A specific problem to interpreting and comparing these data is difficulty in differentiating asthma and chronic obstructive pulmonary disease based on symptoms alone. We tried to overcome this problem by including questions with high specificity for asthma diagnosis into our disease definition. Importantly, tobacco smoking continued to remain a strong risk factor even after adjusting for other confounding factors like age, gender, etc., with similar odds ratio for virtually all forms of tobacco smoking. It therefore appears likely that tobacco smoking truly has an independent association with bronchial asthma in the population we studied.

Another important finding from our data is that the study population at Bangalore had a higher prevalence of asthma as compared to the other three north Indian cities, even after adjustment of other risk factors associated with asthma. While we admit that this data is insufficient to draw any definite conclusions regarding north-south differences in asthma prevalence in India, it certainly opens new areas for looking into ethnic variations in disease prevalence, severity and morbidity in this country with such great heterogeneity. Differences in prevalence have earlier also been reported between different racial and ethnic groups in North America and Europe. Whether these represent true genetic differences, or are merely a result of shared environmental factors, continues to be a matter of debate.

This is the first large scale study on this subject in India and opens several new vistas for further research and investigations. Although the data is truly multicentric, it was not possible to include centres from other parts especially from the Eastern, Central and Western India. Even the southern region, where the prevalence was the highest, was limited to Bangalore. It is envisaged that the study will extend to include other centres to not only come out with data truly representative of national scene, but also to look into epidemiological investigations into familial, genetic and environmental factors influencing atopy, respiratory morbidity and asthma.

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