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ORIGINAL ARTICLE

Prevalence and severity of asthma among Indian school children aged between 6 and 14 years: associations with parental smoking and traffic pollution

Sheetu Singh, MD¹, Bharat Bhushan Sharma, MD², S. K. Sharma, MD³, Mohammed Sabir, MD⁴, Virendra Singh, MD⁵, and ISAAC collaborating investigators^{*5}

¹Department of Pulmonary Medicine, Institute of Respiratory Diseases, Jaipur, India, ²Department of Medicine, SMS Medical College, Jaipur, India, ³Department of Internal Medicine, All India Institute of Medical Sciences, New Delhi, India, ⁴Department of Medicine, Respiratory Division, S.P. Medical College, Bikaner, India, and ⁵Department of Pulmonary Medicine, Asthma Bhawan, Jaipur, India

Abstract

Objective: Phase three of the International Study of Asthma and Allergy in Children (ISAAC) was carried out at various sites in India. The prevalence of asthma symptoms in school children and the effect of environmental tobacco smoke and traffic pollution on the occurrence of asthma were analysed. **Methods:** Two groups of school children, aged 6–7 yr and 13–14 yr, participated according to the ISAAC protocol. Schools were randomly selected and responses to the ISAAC questionnaire were recorded. **Results:** The prevalence of asthma was 5.35% in the 6–7 yr age group and 6.05% in the 13–14 yr age group. The odds ratios (ORs) for the risk of asthma in children with exposure to mild, moderate and heavy traffic pollution compared with minimal traffic pollution were 1.63 (95% CI: 1.43, 1.85), 1.71 (95% CI: 1.49, 1.96) and 1.53 (95% CI: 1.31, 1.78), respectively, in the younger group. Similarly, in the older group, they were 1.19 (95% CI: 1.04, 1.36), 1.51 (95% CI: 1.31, 1.75) and 1.51 (95% CI: 1.29, 1.76). Asthma was associated with maternal smoking [6–7 yr group: OR = 2.72 (2.05, 3.6); 13–14 yr group: OR = 2.14 (1.72, 2.66)] and paternal smoking [6–7 yr group: OR = 1.9 (1.70, 2.11); 13–14 yr group: OR = 1.21 (1.09, 1.34)]. **Conclusions:** The prevalence of asthma was lower in the 6–7 than the 13–14 yr age group. Environmental tobacco smoke and traffic pollution were the factors most strongly associated with asthma in Indian children.

Keywords

Asthma, epidemiology, physiological disorders, pollution, smoking

History

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Introduction

Asthma is caused by the interplay of several genetic and environmental factors, many of which are unknown. Various studies have been conducted to assess the prevalence of asthma; one of these is the International Study of Asthma and Allergy in Childhood (ISAAC), a large study conducted in three phases. Phase I aimed to estimate the prevalence of allergies and asthma in children [1], and phase II attempted to explain the differences in the prevalence of asthma and allergies noted in phase I by studying the differences in risk factors and disease management [2]. Phase III was a repetition

of phase I and aimed to study the global prevalence and severity of asthma and allergies. It was the largest of the three phases and included approximately 1 million children in two age groups, 6–7 yr and 13–14 yr. In contrast, phase I included only half a million children in the 13–14 yr age group [3].

There is a continuous need to identify factors associated with asthma because the prevalence of asthma is rising [4]. Various factors, such as affluence [3], sedentary life style [5,6], environmental tobacco smoke [7] (ETS), childhood viral infections [8] and air pollution [9], have been suggested to be important in the pathogenesis of asthma.

India is a vast country with climatic, geographical, social and cultural differences across its various regions. In India, 18 centres participated in phase III of the ISAAC study. The aim of this paper is to analyse the variations in the symptoms and severity of asthma across different centres in India. We also aimed to study the associations between asthma and environmental factors, such as traffic density and environmental tobacco smoke. These are modifiable factors and can be altered to reduce the morbidity and mortality associated with childhood asthma.

***ISAAC collaborating investigators (India):** Include following - Dr. Jugesh Chhatwal (Ludhiana), Dr. KC Jain (Jodhpur), Dr. Lata Kumar (Chandigarh), Dr. Mohan Keshav Joshi (Mumbai), Dr. Neeta Milind (Pune), Dr. PS Suresh Babu (Davangere), Dr. Shally Awasthi (Lucknow), Dr. Sheila Bhawe (Rasta Peth), Dr. Sundeep Salvi (Pune), Dr. TU Sukumaran (Kottayam), Dr. Vasant A Khatav (Borivali), Dr. Sylvan John Rego (Bangalore)

Correspondence: Professor Virendra Singh, Department of Pulmonary Medicine, Asthma Bhawan, C-93, Shastri Nagar, Jaipur 302016, India. Tel: 0141-2281414; Mob: 919414051212. E-mail: drvirendrasingh@yahoo.com

Methods

The study was conducted at 15 and 18 centres across India for the age groups 6–7 yr and 13–14 yr, respectively, during 2001–03. Permission to analyse data was obtained from principal investigators at 14 and 16 centres for the 6–7 yr and 13–14 yr age groups, respectively. Information from all these centres were gathered, consolidated and analysed. Individual centres selected schools randomly from the surrounding areas. A letter was sent to the principals of the selected schools inviting them to participate in the study. After consent was obtained from the principals, school children of an eligible age, confirmed by school records, were included in the study. Consent was also obtained from the parents of children in both age groups. ISAAC screening questionnaires in Hindi, English, Marathi, Malayalam or Kannada were used according to the dominant language of children in different states of India including Rajasthan, Punjab, Maharashtra, Kerala and Karnataka, respectively. The questionnaires are available on the website (www.isaac.auckland.ac.nz/). The questionnaire included questions regarding the presence of a wheeze, rhinitis, conjunctivitis and eczema. Questions regarding traffic pollution and environmental tobacco smoking were also included in the questionnaire. The questionnaire was distributed to school children after explaining each question. Parents completed the questionnaire for 6–7-yr old students, while students who were 13–14 yr old completed the questionnaires themselves.

The data on 6–7 yr olds were collected from 14 centres and the data on 13–14 yr olds, from 16 centres. Permission to analyse data from two centres in the 13–14 yr age group and one centre in 6–7 yr age group could not be obtained. There were 44 928 and 48 088 children in the 6–7 yr and 13–14 yr age groups, respectively (Tables 1 and 2). The response rate was 91.49% for the 6–7 yr age group and 90.96% for the 13–14 yr age group.

Data analysis

The presence of a wheeze in the past 12 months (i.e. current wheeze) was defined as asthma according to both written and video questionnaires. Subjects with severe asthma were defined, according to the written questionnaire, as asthmatics

with either more than four episodes of wheezing in the past 12 months, more than one night of sleep disturbed by wheezing or speech affected by wheezing. For each group, the prevalence of asthma and its 95% confidence interval were calculated. Crude odds ratios (ORs) with 95% confidence intervals were calculated to assess the association of various risk factors with asthma.

Results

The prevalence of asthma in the studied populations was 5.35% (95% CI: 2.38, 8.32) and 6.05% (95% CI: 4.07, 8.03) in the 6–7 yr and 13–14 yr age groups, respectively. The prevalence of asthma symptoms based on video questionnaires was 4.83% in the 13–14 yr age group; this was lower than the prevalence based on written questionnaires. The various centres that participated in the ISAAC study are depicted on the map of India (Figure 1).

Across the various centres, the minimum prevalence of asthma in the 6–7 yr age group was found in Jodhpur, Rajasthan (2.41%) and the maximum in Kottayam, Kerala (22.99%). In the 13–14 yr age group, the minimum prevalence was in Pimpri, Maharashtra (1.02%) and the maximum in Kottayam, Kerala (15.36%). Kottayam also had the maximum prevalence of severe asthma cases in both the age groups (Tables 1 and 2).

Environmental questions were not included in the study questionnaire in Ludhiana for the 6–7 yr age group and Ludhiana and Chandigarh for the 13–14 yr age group. Thus, both these centres were excluded when calculating the association of various environmental factors with asthma. The environmental questionnaire did not include questions regarding the vaccination status of the children. Nonetheless, all children in the country receive a measles, mumps and rubella vaccine at 9 months of age under the national immunization program. Influenza vaccine is, however, not routinely administered.

The children were also asked questions regarding traffic pollution, and their exposure was graded according to the frequency of trucks passing by children’s homes on weekdays. Minimal, mild, moderate and heavy traffic pollution

Table 1. Prevalence of asthma and severe asthma at various centres in India in the 6–7 yr age group.

Centre	Number	Asthma	Asthma (%)	Severe asthma	Severe asthma (%)	Severe/total asthma
Bangalore	2959	169	5.71	57	1.93	33.73
Davangere	3043	104	3.42	8	0.26	7.69
Jaipur	2545	143	5.62	90	3.54	62.94
Jodhpur	2114	51	2.41	19	0.90	37.25
Kottayam	2619	602	22.99	291	11.11	48.34
Lucknow	3000	104	3.47	43	1.43	41.35
Ludhiana	3225	134	4.16	47	1.46	35.07
Mumbai 16	2865	73	2.55	10	0.35	13.70
Mumbai 18	4862	229	4.71	66	1.36	28.82
Nagpur	4294	164	3.82	66	1.54	40.24
New Delhi	3706	223	6.02	93	2.51	41.70
Pimpri	3838	182	4.74	99	2.58	54.40
Pune	2711	108	3.98	–	–	–
Rasta Peth	3147	119	3.78	58	1.84	48.74
All India	44 928	2405	5.35	947	2.11	39.38

Asthma = number of children with the presence of wheeze in past 12 months; severe asthma = children with symptoms of asthma with either more than four attacks of wheeze in the past 12 months or more than one night sleep disturbed by wheeze or speech affected by wheeze; severe/total asthma = the presence of asthmatic children with severe asthma.

Table 2. Prevalence of asthma by written and video questionnaires and prevalence of severe asthma at different centres in India in the 13–14 yr age group.

Centre	Number	Asthma	Asthma (%)	Video N	Video asthma	Video (%)	Severe asthma	Severe asthma (%)	Severe/total asthma
Bangalore	3440	406	11.80	–	–	–	186	5.41	45.81
Chandigarh	3122	173	5.54	2317	57	2.46	84	2.69	48.55
Borivali	1004	15	1.49	1004	42	4.18	7	0.70	46.67
Davangere	2945	200	6.79	2780	160	5.76	–	–	–
Jaipur	3607	195	5.41	3536	136	3.85	105	2.91	53.85
Jodhpur	2341	124	5.30	2098	450	21.45	57	2.43	45.97
Kottayam	3685	566	15.36	3419	229	6.70	338	9.17	59.72
Lucknow	3000	174	5.80	–	–	–	81	2.70	46.55
Ludhiana	3108	225	7.24	3084	140	4.54	106	3.41	47.11
Bikaner	3059	231	7.55	3059	96	3.14	91	2.97	39.39
Mum 18	2982	136	4.56	–	–	–	74	2.48	54.41
Nagpur	4150	125	3.01	4144	80	1.93	59	1.42	47.20
New Delhi	3469	184	5.30	3469	185	5.33	115	3.32	62.50
Pimpri	3128	32	1.02	3082	42	1.36	15	0.48	46.88
Pune	1983	56	2.82	1951	88	4.51	–	–	–
Rasta Peth	3065	68	2.22	3063	83	2.71	47	1.53	69.12
All India	48 088	2910	6.05	37 006	1788	4.83	1365	2.84	46.91

Asthma = number of children with the presence of wheeze in past 12 months; severe asthma = children with symptoms of asthma with either more than four attacks of wheeze in the past 12 months or more than one night sleep disturbed by wheeze or speech affected by wheeze; severe/total asthma = the presence of asthmatic children with severe asthma.

corresponded to trucks passing by the residences never, seldom, frequently and almost all day, respectively. Figure 2 compares the prevalence of asthmatics among the four groups of traffic exposure. It reveals that increasing exposure to mild and moderate traffic pollution increased the risk of asthma in both the age groups significantly. The odds ratios for the risk of asthma in children with exposure to mild, moderate and heavy traffic pollution as compared with minimal traffic pollution were 1.63 (95% CI: 1.43, 1.85), 1.71 (95% CI: 1.49, 1.96) and 1.53 (95% CI: 1.31, 1.78), respectively, for 6–7 yr olds. Similarly, for the 13–14 yr age group, they were 1.19 (95% CI: 1.04, 1.36), 1.51 (95% CI: 1.31, 1.75) and 1.51 (95% CI: 1.29, 1.76), respectively.

The prevalence of asthma in children exposed to either their mother or father smoking tobacco is shown in Figure 3. ORs were calculated comparing children with asthma and maternal/paternal cigarette smoking. The odds of asthma in children exposed to maternal smoking were 2.7 times the odds in those not exposed in the 6–7 yr age; in the 13–14 yr age group, the odds were 2.1 times higher among children of smoking mothers. However, children exposed to paternal smoking compared with those not exposed had 1.9 times greater odds of reporting asthma in the 6–7 yr age group and 1.2 times greater odds in the 13–14 yr age group. The association with maternal smoking was stronger than with paternal smoking regarding the development of asthma in children of both age groups.

Discussion

Asthma is variable not only with respect to its characteristics but also its prevalence. It has been shown in the ISAAC phase I and III studies that the prevalence of asthma and allergy varies throughout the world [10]. In the present Indian study, the prevalence of symptoms of asthma among children was 5.35% in 6–7 yr olds (i.e. ranging from 2.41% in Jodhpur to 22.99% in Kottayam) and 6.05% in 13–14 yr olds (i.e. ranging from 1.02% in Pimpri to 15.36% in Kottayam). The prevalence of asthma in children in India is lower than the global

prevalence (i.e. 11.5% and 14.1% in the 6–7 yr and 13–14 yr age groups, respectively) [3].

According to the ISAAC questionnaire, severe asthma was defined as asthmatics with either more than four episodes of wheezing in the past 12 months, more than one night of sleep disturbed by wheezing or speech affected by wheezing. The prevalence of symptoms suggestive of severe asthma was also lower in Indian centres compared with the global prevalence. It was 2.11% in the 6–7 yr age group and 2.84% in the 13–14 yr age group in India. In comparison, the global average was 4.9% and 6.9% in the two age groups, respectively [3].

The estimated prevalence of asthma in the older age group based on the written questionnaire (6.02%) was more than that estimated from the video questionnaire (4.83%). The discrepancy between our estimates was less than the discrepancy found in a global analysis which estimated a prevalence of 14.1% *via* a written questionnaire and 8.7% *via* a video questionnaire [3]. Furthermore, 86.3% of patients who answered affirmatively regarding the presence of a wheeze in the past 12 months in the video questionnaire confirmed this response on the written questionnaire.

There is a paucity of large-scale epidemiological Indian studies on the prevalence of asthma. However, the available regional studies indicate a lower prevalence of asthma compared with the global literature [11–13]. Observations from the cumulative national ISAAC phase III data also support this notion. No single reason is likely to explain the lower prevalence of asthma in India. It may be related to allergy priming in early life in Indian children. India is a developing country where gastrointestinal infections are common in early life. These preferentially stimulate the Th-1 response rather than the Th-2 response, and may lead to a lower prevalence of asthma [14]. In addition, a variety of social, cultural and environmental factors must be considered in this context. These factors might favourably have reduced the development of asthma in the Indian population.

The present study also revealed great inter-centre variation in India, with Kottayam reporting the highest prevalence of



Figure 1. The map of India showing the distribution of the ISAAC study centres.

asthma in both the age groups. Jodhpur reported the lowest prevalence in the 6–7 yr age group, and Pimpri reported the lowest prevalence in the 13–14 yr age group. India is a vast country. The northern part is dry and has extreme temperatures. South India is surrounded by seas on three sides; therefore, there is less fluctuation in the temperature and more humidity. In addition to climatic variation, there are differences in vehicular exhaust, genetic variation and diet; the staple grain is wheat in north India and rice in south India. There are also differences in vegetation and pollen exposure in the two

regions. Another factor that may contribute to differences in patterns of asthma and allergic disorders across the nation is the type of soil particles, which differ in north and south India.

The prevalence of severe asthma among asthmatics was 39.38% in the 6–7 yr age group, which is comparable with the world average of 38.5%. Similarly, 46.91% of asthmatics in the 13–14 yr age group had severe asthma, compared with a world average of 43.3%.

Traffic pollution, particularly diesel exhaust particles [15], and parental smoking have been associated with a higher

Figure 2. The prevalence (percentage) and odds ratio of asthma according to traffic pollution exposure in the 6–7 and 13–14 yr age groups.

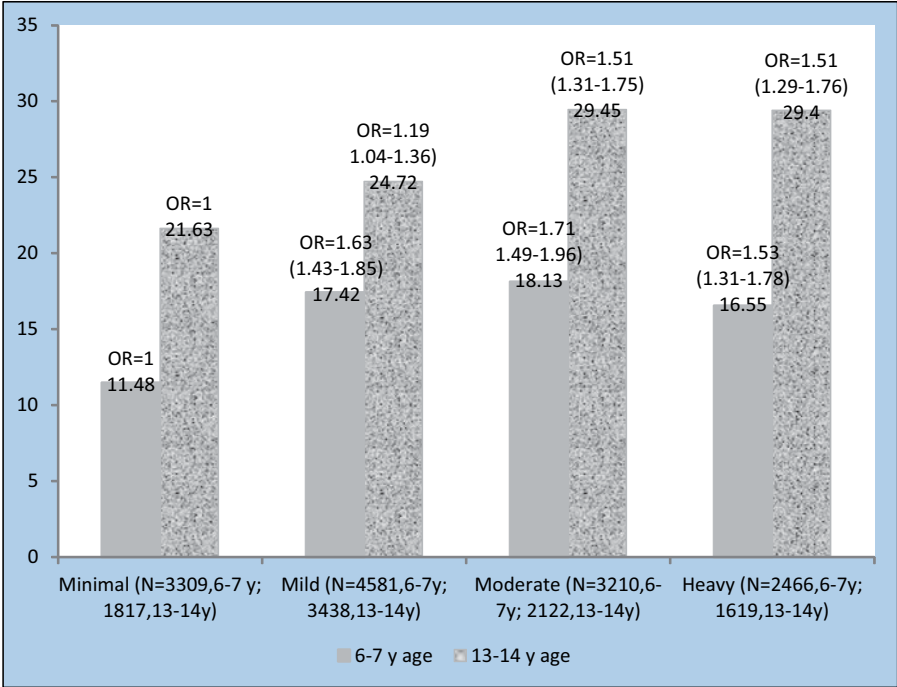
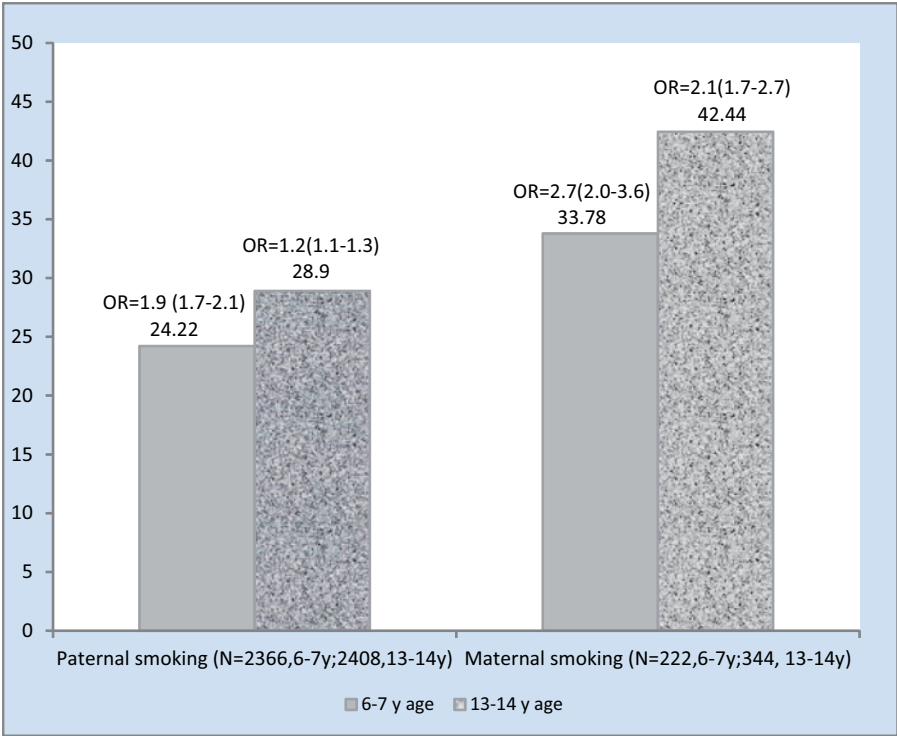


Figure 3. The prevalence (percentage) and odds ratio of asthma according to parental smoking in the 6–7 and 13–14 yr age groups.



prevalence of asthma, but these were not substantiated in Indian studies. The present phase III Indian data show that contact with heavy traffic pollutants was associated with a higher prevalence of asthma. Children in the 6–7 yr age group exposed to mild, moderate and heavy traffic exposure had 1.63, 1.71 and 1.53 times higher odds of developing asthma compared with the minimal traffic exposure group. Similarly, children in the 13–14 yr age group exposed to mild, moderate and heavy traffic exposure had 1.19, 1.51 and 1.51 times higher odds of developing asthma compared with the minimal

traffic exposure group (Figure 2). However, there was no difference between the prevalence of asthma in children who experienced moderate and heavy exposure. Moderate and severe traffic pollution was defined by trucks passing by the house frequently and almost the whole day, respectively. These findings are similar to the ISAAC worldwide data, which also showed an association of asthma with the frequency of truck traffic [16]. The levels of sulphur dioxide (SO₂), nitrous dioxide (NO₂) and particulate matter (PM₁₀) were also retrieved for eight out of 16 study sites during that

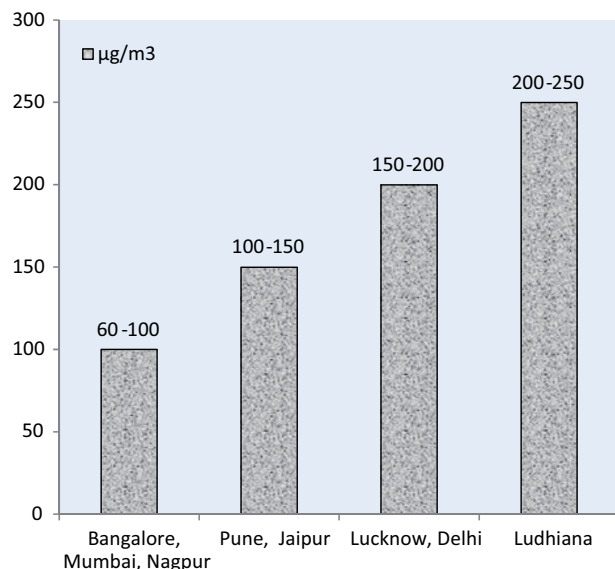


Figure 4. Levels of particulate matter 10 µm in size (PM10) in µg/m³ during study period in eight cities.

period. The SO₂ and NO₂ levels were less than the permissible upper limits at all the centres. However, during the study period, all eight centres under national air quality surveillance (Figure 4) had PM10 levels above the permissible limits (permissible limit is 60 µg/m³) [17]. Previous cross-sectional and case-control studies have also demonstrated indirectly that the proximity of a residence to a road with heavy traffic is associated with a higher occurrence of respiratory symptoms, increased sensitization and reduced pulmonary function [9,18–20]. It has been postulated that NO₂, SO₂ and suspended particles present in traffic pollution may lead to an increased occurrence of asthma [21,22]. However, a few studies report the contrary. Molter et al. [23] studied the association of air pollutant levels and the prevalence of asthma in children. They did not find any significant association between the two. Similarly, a study by Oftedal et al. [24] did not show a positive correlation between traffic pollution and asthma.

We also found an association between environmental tobacco smoking and the prevalence of asthma symptoms. Passive smoking increases bronchial hyper-reactivity and the tendency to develop allergies and asthma [25]. The prevalence of asthma in children of smoking mothers was higher (33.78% and 42.44% in the 6–7 yr and 13–14 yr olds, respectively) than in the children of smoking fathers (24.22% and 28.9%, respectively). This was similar to the global data, which suggested that maternal smoking was more closely related to childhood asthma.

A large study population and strict adherence to the ISAAC protocol were strengths of the present study. This is the first study to address the prevalence and risk factors of asthma in Indian children. However, there were certain drawbacks of the study. The questionnaires were subjective, and answers varied based on the perception of the child or parent. The gold standard for the diagnosis of asthma is an improvement of greater than 12% and 200 ml of forced expiratory volume in the first second (FEV1) after bronchodilator inhalation during spirometry [26]. An alternative standard for diagnosis is a bronchial challenge test showing a

≥20% reduction in FEV1 after a <16 mg/ml methacholine challenge [26]. The classification of asthma as the presence of wheezing in the past 12 months may have misclassified other causes of wheeze as asthma. All the scientific studies based on questionnaires rely mostly on subjective information. A number of previous studies have used similar methodologies to those used in this paper, and many have specifically used the ISAAC questionnaire [27]. The results of these studies suggest that the ISAAC questionnaire correlates well with physician-based diagnosis [28], physiological parameters [29,30] and other questionnaires [30,31]. One potential advantage of using consistent epidemiologic tools is that the resultant data are amenable to future meta-analyses.

Implications of the results of our study are manifold. Evidence regarding the harmful effects of parental smoking and environmental tobacco smoke can promote smokers to quit smoking. Therefore, this study can be used in public health motivational strategies. Similarly, harmful effects of traffic pollution on the respiratory health of children may help formulate local as well as national policies to restrict the entry of vehicle near households and adapt better norms for exhaust pollution generated from vehicles. Alternate energy fuels, which do not pose a health hazard, also need to be developed for vehicles.

Future research studies may be planned to assess the prevalence of asthma in children using objective tests. Further, the severity of exposure to environmental triggers may be assessed using objective scales like hours of passive smoking exposure and real time concentration of air pollutants in the atmosphere. Additional demographic and health history information, including exposure to viral or bacterial infections and vaccination details may also be elicited and analysed in future studies.

Conclusions

It can thus be concluded that the prevalence of asthma is lower in India than it is globally according to the statistics from the ISSAC study. Environmental tobacco smoke and traffic pollution were associated with the presence of asthma in children.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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