Respiratory symptoms, asthma, exercise test spirometry, and atopy in schoolchildren from a Lima shanty town

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Abstract

***Background*—Little is known about the associations between symptoms of asthma, pulmonary function tests, and atopy in developing countries. While asthma in children is often associated with atopy, some studies of wheezing illness have found little or no association, leading to suggestions that there are subgroups of wheezing illness. The ISAAC study recently reported that the prevalence of reported asthma symptoms in Lima, Peru was among the highest in the world, but did not report on the atopic status of the subjects.**

***Methods*—A cross sectional survey was conducted of children aged 8–10 years who had previously participated in a cohort study of respiratory and diarrhoeal illnesses in infancy. Questionnaires were administered asking about respiratory symptoms and asthma diagnoses, pulmonary function tests were performed before and after exercise on a treadmill, and atopy was determined from skin prick tests and specific serum IgE levels.**

***Results*—A total of 793 children participated in the survey. The prevalence of asthma related symptoms in the last 12 months was 23.2%, but only 3.8% of children reported a recent asthma attack. The mean differences in pretest percentage predicted forced expiratory volume in one second (FEV_1) were 8.1% (95% CI 2.4 to 13.8) between children who did and did not report an asthma attack in the last 12 months, and 5.3% (95% CI 2.8 to 7.9) in children who did and did not report respiratory symptoms. The corresponding differences in mean percentage fall in FEV_1 after exercise were 3.1% (95% CI –1 to 7.1) and 5.1% (95% CI 3.4 to 6.8). Recent asthma or respiratory symptoms were not associated with atopy in this population (odds ratios 1.29 (95% CI 0.56 to 2.97) and 0.91 (95% CI 0.61 to 1.37), respectively).**

***Conclusions*—Most asthma in these children was unrecognised and mild. Asthma and asthma symptoms in this population do not seem to be related to atopy.**

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Keywords: asthma; atopy; schoolchildren; Peru

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The prevalence of childhood asthma is increasing in developed countries[1–4] and appears to be associated with a corresponding increase in the prevalence of atopy.[5 6] The International Study of Asthma and Allergies in Childhood (ISAAC) study showed a wide variation in the prevalence of a reported asthma diagnosis and asthma symptoms between different countries in representative samples of schoolchildren.[7] Although rates of self-reported asthma were generally highest in Western and English speaking countries, many South American countries also had high prevalence rates and Peru had the highest 12 month prevalence of asthma symptoms from video questionnaires.[7] Little is known about risk factors for asthma in developing countries, but there is evidence that prevalence rates are higher in urban than in rural areas.[8 9] Few surveys in developing countries have included objective measures of respiratory function or airway responsiveness. Here we report the results of a study of asthma and associated symptoms, respiratory function, and atopy in children aged 8–10 years in a deprived shanty town in Lima, Peru.

Methods

STUDY SITE

The study was undertaken between June and December 1997 in a deprived urban area of Lima characterised by a dry desert climate, dusty environment, poor quality housing, and lack of sanitation services.[10 11] There is no rainfall but frequent sea mists, amounting to at most drizzle, occur on most mornings in winter and humidity is high. Average temperatures range from 16°C in winter to 24°C in summer, and humidity is 80% in winter and 60–70% in summer. The study was conducted during a year in which the "el Niño" weather phenomenon had a profound effect on the climate with much higher temperatures than expected during winter.

STUDY POPULATION

The population of this area is mestizo—a mix of indigenous Andean Indian and mainly European stock, most of whom migrated from rural areas over the last 30 years or are the offspring of rural emigrants.

A cross sectional survey was conducted of children aged 8–10 years who had previously participated in a cohort study of respiratory and diarrhoeal illnesses when they were aged 3–36 months.[12–14] Participants in the cohort study were recruited from all newborn infants identified by district census whose parents gave consent to participate. Families of children who had participated in the cohort study were revisited and invited to take part in this new

Table 1 Questions on respiratory symptoms in the last 12 months, with English translations and prevalence of reported symptom

Question	*Spanish*	*English translation*	*Prevalence (%)*
1	A el (ella) le ha silbado el pecho (ha tenido como pitos en el pecho/sibilantes) alguna vez en los últimos 12 meses? (si no entiende describir como es el sonido)	Has he (she) had a wheeze (had a whistling sound from the chest/wheezes) at any time in the last 12 months? (if not understood, describe the sound)	9.5
2	Alguna vez en los últimos 12 meses el (ella) se\ha quejado de que se le cierra su pecho?	Has he (she) complained of chest tightness at any time in the last 12 months?	9.3
3	Alguna vez en los últimos 12 meses ha tenido respiración agitado?	Has he (she) had agitated breathing at any time in the last 12 months?	11.2
4	Se ha despertado con la sensatión que se le "cierra el pecho" en los últimos 12 meses?	Has he (she) woken with a feeling of tight chest at any time in the last 12 months?	3.4
5	Alguna vez en los últimos 12 meses ha tenido dificultad para respirar porque le "faltaba aire"? (excluyendo la agitación que es normal despues de correr:jugar)	At any time in the last 12 months has he (she) had difficulty breathing because of shortness of (not enough) breath? (Excluding the normal breathlesness after running or playing)	9.0
6	Alguna vez en los últimos 12 meses, se ha despertado por la noche porque le "faltaba aire"?	At an time in the last 12 months has he (she) woken at night because of shortness of breath?	5.7
7	Alguna ves en los últimas 12 meses, su hija (hijo) se despertó en la noche por un ataque de tos?	During the last 12 months, has your child ever woken at night because of an attack of coughing?	34.9
8	Ha tenido un ataque de asma ó broncospasmo en los últimos 12 meses?	Has (your child) had an attack of asthma or bronchospasm in the last 12 months?	3.8

study. Of 1477 families revisited, only 12.4% refused to participate. The study was approved by the ethics committees of the Instituto de Investigacion Nutricional and the London School of Hygiene and Tropical Medicine. Parents of participating children gave written informed consent. More than 98% of the children were attending school at the time of the survey.

PROCEDURES

A questionnaire on respiratory symptoms and past medical history which included some of the ISAAC core questions on wheeze and asthma diagnosis[15] was administered by trained field workers to the mother or normal caretaker of each child. Questions on respiratory symptoms were based on the results of a pilot study in 91 children living in the same area and on Spanish phrases commonly used to describe asthma symptoms in known asthmatic children. Table 1 shows each question in Spanish together with its English translation. Parents/caretakers were also asked whether the child had ever had asthma or bronchospasm, whether this had been diagnosed by a doctor, whether they had ever received inhalant medication or the commonly used bronchodilators, and whether there was a family history of asthma. Sociodemographic information including parental age and education, housing type, family size, family history of asthma, and parental smoking was also collected.

The children were examined by one doctor (TH) using a standardised protocol and pulmonary function tests were undertaken by one nurse (SM) using a portable Rennaissance spirometer which was calibrated every day. Tests were done during the mornings and afternoons. The children were shown how to use the apparatus and allowed up to three practice blows before recording began. The highest forced expiratory volume in one second (FEV_1) of three blows was considered. Children with baseline FEV_1 of $\leqslant$70% predicted value (Polgar values, corrected for age and height) were treated with inhaled salbutamol (metered dose inhaler (MDI) and spacer) and pulmonary function tests were repeated. Children with FEV_1 >70% predicted exercised on a gradient electric treadmill (inclination 8°) for 4 minutes after reaching a heart rate of 80% calculated maximum. All children breathed ambient air during the test. Pulse rates were continuously measured on a Vanguard pulse monitor and treadmill speed was adjusted to maintain the child's heart rate within the target range. Nasal clips were not used as they seemed to make it more difficult for the children to complete the spirometric tests successfully. Forced vital capacity (FVC) manoeuvres were performed in the upright position.

FEV_1 was measured at 5 minute intervals after stopping exercise for up to 30 minutes and the best of at least three blows at each interval was recorded. The percentage reduction in FEV_1 after exercise was calculated by comparing the lowest recorded post-exercise FEV_1 with the best pre-exercise FEV_1. Children whose FEV_1 fell by $\geqslant$15% after exercise were given inhaled salbutamol and a repeat test was performed. Information on daily local maximum, minimum and mean ambient temperatures and humidity indicated little variation with temperatures consistently between 21°C and 26°C and humidity of 82–90%.

Skin prick tests were used to assess sensitisation to cat hair, house dust mite (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*), cockroach (mix 6585), and *Penicillium* mix using antigens supplied by Bayer Corporation, Spokane, USA. This choice of allergens was based on the experience of local allergy specialists. Histamine hydrochloride was used as a positive control and diluent fluid was the negative control. The mean of two diameters of each weal was measured after 5, 10 and 15 minutes. The size of the reaction for each allergen was defined as the maximum value minus the maximum negative control value. Reactions of $\geqslant$3 mm were considered positive and children with one or more positive reactions were defined as atopic. Venous blood was collected and the serum separated, put into aliquots, and stored at –20°C until transport. Specific IgE was measured to *Dermatophagoides pteronyssinus*, cat, and cockroach antigens using the Pharmacia CAP system (Pharmacia and Upjohn, Uppsala, Sweden). Values above 0.35 kU/l were considered indicative of the presence of specific IgE. We did not have sufficient financial resources to measure total IgE as well as specific IgE.

DATA ANALYSIS

Data were entered into a computer database using range and consistency checks. After data cleaning all analyses were performed using STATA version 6.0. The means of continuous variables in different groups were compared using *t* tests while logistic regression was used to compare the odds of binary outcomes.

Results

A total of 991 children from the original cohort were approached and invited to participate in the study. Of these, 183 (18.5%) declined, 11 (1.1%) were unable to perform spirometric tests (five had a cough sufficient to interfere with the test and six were unable to coordinate blowing), and for a further four no information on respiratory symptoms was obtained because there was no suitable respondent. The remaining 793 (80.0%) underwent pulmonary function testing.

PREVALENCE OF RESPIRATORY SYMPTOMS AND ASTHMA

A total of 164 (20.7%) children were reported to have had asthma (n=79) or bronchospasm (n=140) or to have been administered inhaled bronchodilators (n=141) at any time since birth. No children had received bronchodilators without a diagnosis of asthma or bronchospasm. The majority of these children (n=139, 84.8%) started to wheeze in their first year of life and only eight (4.9%) reported the onset after the age of 3 years. Approximately half (n=89, 54.3%) reported no further attacks after reaching 4 years of age. Nineteen (11.6%) reported having been admitted to hospital because of asthma while 59 (36.0%) reported having required emergency treatment for asthma.

The prevalence of respiratory symptoms during the previous 12 months is shown in table 1. Approximately 10% of children reported wheezing, chest tightness, or difficulty in breathing in the previous 12 months, but waking at night with symptoms other than cough was reported less frequently. Waking with cough over the last 12 months was reported by 276 children (34.9%). Symptoms were usually reported to occur in the presence of signs of upper respiratory infections—for example, wheeze in the last 12 months was reported by 9.5% of children, but by only 2.8% in the absence of signs of upper respiratory infection (data not tabulated). Only 30 (3.8%) of children reported an asthma attack in the last 12 months; all of these also reported respiratory symptoms over the same period. The number of asthma attacks in the last 12 months reported by these 30 children was one (n=9), two (n=13), three (n=4), four (n=3), and five (n=1). Of these children, four (13.3%) reported having been admitted to hospital because of asthma while 21 (70%) reported having required emergency treatment for asthma.

SPIROMETRIC TESTS

The median variance in the pretest FEV_1 was 1.8% (mean 4.1%) and the post-test median values were 2.6–2.9% (mean 3.9–4.4%). Mean pretest FEV_1 was 104% of height corrected reference values for sea level.

Of the 793 children in whom spirometric tests were performed before exercise, 22 (2.8%) had FEV_1 <70% predicted for age and height. The remaining 771, together with a child with pre-exercise FEV_1 69.6% predicted, repeated the spirometric tests after exercise testing. All children who exercised completed the test and none complained of symptoms during or after the test. The child who exercised despite a pre-exercise FEV_1 of <70% predicted had a 28% post-test reduction, was treated with salbutamol, and suffered no ill effects. Of the 772 children who did the exercise test, 179 (23.2%) had a reduction in FEV_1 after exercise of >15%. Thus, a total of 200 (25.2%) children (21 FEV_1 <70% predicted, 178 >15% reduction in FEV_1 after exercise, one both) were considered to have abnormal spirometric results consistent with asthma.

Table 2 shows the mean percentage predicted FEV_1 before exercise testing according to reported asthma, bronchospasm, or bronchodilator therapy at any time, and according to reported respiratory symptoms in

Table 2 Association of pre-exercise % predicted FEV_1 with respiratory symptoms and asthma

	Children without symptoms		*Children with symptoms*			
	N	*Mean % of predicted value (95% CI)*	*N*	*Mean % of predicted value (95% CI)*	*Difference in means (95% CI)*	*p Value*
At any time:						
Asthma	714	104.4 (103.3 to 105.6)	79	100.1 (96.7 to 103.6)	4.3 (0.7 to 8.0)	0.019
Bronchospasm	653	104.6 (103.5 to 105.8)	140	101.1 (98.0 to 104.2)	3.5 (0.7 to 6.4)	0.015
Bronchodilator therapy†	623	104.8 (103.6 to 105.9)	141	101.0 (98.2 to 103.7)	3.8 (1.0 to 6.6)	0.007
Asthma to bronchospasm or bronchodilator therapy	629	104.7 (103.6 to 105.9)	164	101.4 (98.5 to 104.2)	3.4 (0.7 to 6.0)	0.014
In the last 12 months (numbers refer to question numbers in table 1):						
(1) Wheeze‡	717	104.4 (103.3 to 105.5)	75	100.3 (96.2 to 104.3)	4.1 (0.4 to 7.8)	0.029
(2) Chest tightness	719	104.5 (103.4 to 105.6)	74	99.5 (94.7 to 104.3)	4.9 (1.2 to 8.7)	0.009
(3) Agitated breathing	704	104.8 (103.7 to 105.9)	89	97.8 (93.4 to 102.1)	7.1 (3.6 to 10.5)	<0.001
(4) Waking with tight chest	766	104.2 (103.2 to 105.3)	27	97.4 (89.8 to 105.1)	6.8 (0.8 to 12.8)	0.026
(5) Shortness of breath	722	104.6 (103.5 to 105.7)	71	97.8 (92.9 to 102.6)	6.9 (3.1 to 10.6)	<0.001
(6) Waking with shortness of breath	748	104.4 (103.3 to 105.5)	45	97.9 (91.8 to 104.0)	6.5 (1.8 to 11.2)	0.007
(7) Waking with cough‡	516	104.0 (102.7 to 105.3)	276	104.2 (102.2 to 106.1)	–0.1 (–2.4 to 2.1)	0.915
(8) Asthma attack	763	104.3 (103.2 to 105.4)	30	96.2 (88.2 to 104.3)	8.1 (2.4 to 13.8)	0.005
Any respiratory symptom of asthma*	609	105.3 (104.1 to 106.4)	184	99.9 (97.1 to 102.7)	5.3 (2.8 to 7.9)	<0.001

*Any of symptoms listed in questions 1 to 6 (see table 1) during the last 12 months. †Information not available for 29 children. ‡Information not available for one child.

Table 3 Association of maximum % fall in FEV_1 after exercise with respiratory symptoms and asthma

	Children without symptoms		Children with symptoms			
	N	*Mean % reduction (95% CI)*	*N*	*Mean % reduction (95% CI)*	*Difference in means (95% CI)*	*p Value*
At any time:						
Asthma	697	9.5 (8.7 to 10.2)	75	12.1 (9.4 to 14.8)	–2.6 (–5.1 to –0.1)	0.038
Bronchospasm	641	9.5 (8.7 to 10.2)	131	11.0 (9.0 to 13.0)	–1.6 (–3.5 to 0.4)	0.112
Bronchodilator therapy†	612	9.3 (8.5 to 10.1)	133	11.4 (9.3 to 13.5)	–2.0 (–4.0 to –0.1)	0.038
Asthma to bronchospasm or bronchodilator therapy	618	9.2 (8.5 to 10.0)	154	11.7 (9.7 to 13.6)	–2.5 (–4.2 to –0.6)	0.010
In the last 12 months (numbers refer to question numbers in table 1):						
(1) Wheeze‡	701	9.5 (8.7 to10.2)	70	12.0 (9.4 to14.5)	–2.5 (–5.0 to 0.0)	0.054
(2) Chest tightness	704	9.0 (8.3 to 9.8)	68	17.0 (14.0 to 19.9)	–7.9 (–10.5 to–5.4)	<0.001
(3) Agitated breathing	692	9.4 (8.6 to 10.1)	80	12.8 (10.5 to 15.1)	–3.4 (–5.8 to –1.0)	0.005
(4) Waking with tight chest	748	9.7 (8.9 to 10.4)	24	11.2 (7.6 to 14.8)	–1.5 (–5.8 to 2.7)	0.471
(5) Shortness of breath	709	9.4 (8.7 to 10.2)	63	13.2 (10.0 to 16.4)	–3.8 (–6.4 to –1.1)	0.005
(6) Waking with shortness of breath	732	9.6 (8.9 to 10.3)	40	11.8 (7.7 to 16.0)	–2.2 (–5.5 to 1.1)	0.188
(7) Waking with cough‡	505	9.6 (8.7 to 10.5)	267	9.9 (8.8 to 11.1)	–0.3 (–1.9 to 1.2)	0.660
(8) Asthma attack	746	9.6 (8.9 to10.4)	26	12.7 (8.6 to16.8)	–3.1 (–7.1 to 1.0)	0.136
Any respiratory symptom of asthma*	603	8.6 (7.8 to 9.4)	169	13.7 (11.9 to15.5)	–5.1 (–6.8 to –3.4)	<0.001

*Any of the symptoms listed in table 1 during the last 12 months.
†Information not available for 29 children.
‡Information not available for 1 child.

the previous 12 months. Mean FEV_1 was lower in all groups of children reporting past or recent asthma or wheeze or recent respiratory symptoms, except that waking with cough was not associated with mean FEV_1. A total of 184 children (23.2%) reported one or more of the respiratory symptoms listed in questions 1–6 of table 1 over the previous 12 months.

Of the 21 children with pre-exercise FEV_1 <70% predicted who did not do exercise testing, the mean percentage improvement following salbutamol inhalation was –0.1% in six children who did not report symptoms, 16.3% in 11 children who reported symptoms but no recent asthma attacks, and 19.0% in four children reporting recent symptoms and asthma attacks. The mean percentage reduction in FEV_1 after exercise was greater in all groups with symptoms (table 3), although again there was little association with waking with cough over the previous 12 months. For both pre-exercise FEV_1 and percentage improvement after exercise, the largest mean differences were between children who did and did not report chest tightness or recent asthma, and who did and did not report recent respiratory symptoms. Figure 1 summarises the association between a history of asthma or bronchospasm, recent respiratory symptoms and asthma, and abnormal spirometric results.

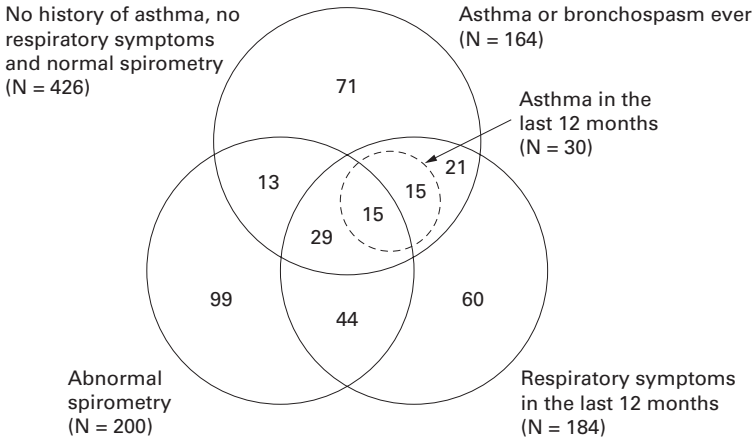

Figure 1 Association between diagnosed asthma, recent symptoms, and abnormal pulmonary function tests.

Spirometric tests were repeated in 93 children, of whom four had pre-exercise FEV_1 <70% predicted at the initial testing and so did not have post-exercise measurements. The repeat tests were done at a mean of 83 days (range 9–168 days) after the first tests. The correlations between pre-exercise FEV_1 on the two occasions and minimum post-exercise FEV_1 on the two occasions were both 0.78. However, the correlation in post-exercise reduction in FEV_1 on the two occasions was lower (0.37). Of 31 children who had a reduction in FEV_1 after exercise of >15% at their first test, 11 (35.5%) also had a reduction of >15% at repeat testing while, of 58 in whom the reduction in FEV_1 after exercise was <15%, six (10.3%) had a reduction of >15% at repeat testing.

RESULTS OF ALLERGY TESTING

Of the 793 children, skin prick tests were performed in 757 (95.5%). Positive reactions to one or more antigens were seen in 181 (23.9%), the most common allergic response being to *D pteronyssinus* and *D farinae* (n=92, 12.2% for each). Because of funding constraints, specific serum IgE levels were measured in serum from the 363 (45.8%) children for whom most information was available from the studies during infancy. Of these, skin prick tests were performed in 347. There were moderately strong associations between specific IgE and skin test reactions to the corresponding allergen (table 4). Associations between specific IgE and the presence of any reaction to a skin test were weaker. There was no evidence of associations between atopy (any skin test reaction) and recent asthma, recent symptoms, or abnormal spirometric results. Only eight children (28.6%) with recent asthma were atopic (table 5). There was weak evidence for an association between asthma in the last 12 months and the presence of specific IgE (odds ratios 2.03 (95% CI 0.79 to 5.24), 1.84 (95% CI 0.63 to 5.32), and 3.13 (95% CI

Table 4 Association between atopy measured by skin test reaction and specific serum IgE

	Negative (%)	*Positive (%)*	*OR (95% CI)*
Skin test ≥3 mm more than control with corresponding allergen:			
Specific mite IgE*	73/305 (23.9)	19/36 (52.8)	3.55 (1.73 to 7.30)
Specific cockroach IgE	48/325 (14.8)	9/22 (40.9)	4.00 (1.59 to 10.0)
Specific cat IgE	25/324 (7.7)	4/23 (17.4)	2.52 (0.79 to 8.02)
Any skin test 3 mm more than control:			
Specific mite IgE*	59/257 (23.0)	33/84 (39.3)	2.17 (1.27 to 3.70)
Specific cockroach IgE	34/261 (13.0)	23/86 (26.7)	2.44 (1.33 to 4.47)
Specific cat IgE	18/261 (6.9)	11/86 (12.8)	1.98 (0.89 to 4.40)

* Mite IgE performed in 341 blood samples.

Table 5 Association of atopy (defined as any skin test reaction at least 3 mm more than control) with respiratory symptoms and asthma

	Any skin test 3 mm more than control		
	Negative (%)	*Positive (%)*	*OR (95% CI)*
Asthma or bronchospasm ever	111/576 (19.3)	44/181 (24.3)	1.35 (0.90 to 2.00)
Symptoms in last 12 months	133/576 (23.1)	39/181 (21.5)	0.91 (0.61 to 1.37)
Asthma attack in last 12 months	20/576 (3.5)	8/181 (4.4)	1.29 (0.56 to 2.97)
Pre-test FEV_1 <70%	14/576 (2.4)	6/181 (3.3)	1.38 (0.52 to 3.64)
15% reduction in FEV_1	138/562 (24.6)	35/176 (19.9)	0.76 (0.50 to 1.16)

FEV_1 = forced expiratory volume in one second.

0.96 to 10.18) for mite, cockroach, and cat IgE, respectively (data not tabulated)).

Discussion

In a survey of 8–10 year old children living in a deprived urban area of Lima, the cumulative prevalence of a diagnosis of asthma was 20.7%. Only 3.8% of the children reported a recent asthma attack, but 23.2% of the children reported respiratory symptoms suggestive of asthma. Both asthma and respiratory symptoms suggestive of asthma in the previous 12 months were associated with lower pre-exercise FEV_1 and greater falls in FEV_1 after exercise. Although there were moderately strong associations between the results of skin prick tests and measures of serum IgE, we found little evidence of associations between either measure of atopy and respiratory symptoms or asthma.

The onset of asthma was usually in the first 3 years of life. As shown in fig 1, of the children who had early wheezing about half resolved while the other half continued to have symptoms compatible with asthma. As previously reported, most infants and toddlers who wheeze do not go on to develop asthma.[16] Asthma attacks are reported more frequently during the winter (April to November) in Lima. However, this study was undertaken during a year in which the el Niño weather phenomenon meant that there had been no winter weather in the preceding 12 months; this might have reduced the incidence of asthma attacks in these children. On the other hand, few additional attacks were reported when the previous 24 months rather than the previous 12 months were considered (data not shown). The relatively high proportion of children reporting use of bronchodilators at some time (18.5%) reflects the fact that this population, though deprived, has relatively good access to health care. Bronchodilators are often prescribed although, because of cost, salbutamol syrup is given more often than inhalers.

Although the children were aged 8–10 years and had no previous training in pulmonary function tests, nearly all were able to perform the tests and variances were satisfactory. Tests were carried out breathing ambient air although humidity was consistently high. This might be expected to reduce the quality of the lung function data, but abnormal spirometric values were nonetheless clearly associated with recent reported asthma and respiratory symptoms. As might be expected, the reproducibility of post-exercise reduction in FEV_1 was modest.

The prevalence of recent asthma related symptoms was much higher than that of reported asthma attacks. Given that such symptoms were associated with reduced pre-exercise lung function, reversible airways obstruction, and with exercise induced bronchoconstriction, it appears that the low prevalence of reported asthma in this population is due to underdiagnosis.

There were moderate associations between specific IgE and the presence of skin reactions to the same allergen. However, asthma and asthma related respiratory symptoms were not associated with atopy measured by skin prick tests in this population. While some studies have demonstrated atopy to be strongly associated with childhood asthma,[17–19] this is not a consistent finding.[20] Little information is available from developing countries. Yemanerbehan *et al* found an association between atopy and asthma in an urban area of Ethiopia but not in a rural area.[9] We have information on early childhood illnesses in these children and plan further analyses to elucidate the role of early infections on the development of later asthma and atopy.

An asthma attack within the last year was reported for only 30 (3.8%) of this group of children. Our results suggest that it was necessary to ask a series of questions about symptoms in order to identify children with possible asthma. The composite definition was used because local respiratory physicians report that asthmatic children often complain of chest tightness or agitated breathing, and our pilot study showed that these symptoms were associated with asthma. Question 1 in table 1 was designed to be similar to the ISAAC study core question for asthma. If we had relied only on this question, we would have estimated the prevalence of asthma related symptoms as 9.5% instead of 23.2%. Furthermore, mean differences in the pre-exercise percentage predicted FEV_1 and post-exercise improvement between children who did and did not report wheeze were smaller than mean differences for the combined symptoms or for reported asthma attack.

The ISAAC study in Lima reported a 26% prevalence of wheezing,[15] considerably higher than the prevalence of wheezing found in our study using a similar question and one of the highest reported prevalences worldwide. The cumulative prevalence of asthma in our study (20.7%) was lower than the 28% reported in the ISAAC study.[15] Children in the ISAAC study were older (13–14 years), were selected from a middle class area, and information was self-reported compared with caretaker reporting in our study. It would be of interest to

explore further whether the discrepancy between our study and the ISAAC study is due to variation in the prevalence of asthma symptoms by age or in different socioeconomic groups or to other factors.

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