

Epidemiological studies of the very high prevalence of asthma and related symptoms among school children in Costa Rica from 1989 to 1998

Soto-Quiros ME, Soto-Martinez M, Hanson LÅ. Epidemiological studies of the very high prevalence of asthma and related symptoms among school children in Costa Rica from 1989 to 1998. *Pediatr Allergy Immunol* 2002; 13: 342–349. ©2002 Blackwell Munksgaard

The aim of our study was to determine the prevalence of asthma and related respiratory symptoms in school children from Costa Rica during the last 10 years, from 1989 to 1998. Using nationally representative samples of school children from Costa Rica during the last 10 years we have performed three studies. Altogether 9931 children were investigated. The age groups: study I, 5–17 years ($n = 2682$), study II, 6–7 years ($n = 2944$), 13–14 years ($n = 3200$) and study III, 10 years ($n = 1105$). The diagnostic criteria for asthma used in these studies was as follows: study I (1989), diagnosis by a doctor in combination with the presence of four kinds of respiratory symptoms; studies II (1995) and III (1998), history of wheeze in the past 12 months. The two latter were part of the International Study of Asthma and Allergies in Childhood (ISAAC).

A very high prevalence of a history of wheezing was found in the three studies (46.8%, 42.9%, and 45.1%) as well as a diagnosis of asthma (23.4%, 27.7% and 27.1%). The physician's diagnosis of asthma reported in the first study (23%) increased from 23.1 in study II to 27.7% in study III ($p = 0.004$). This increment could be a real increase in asthma prevalence, or be due to a better awareness about asthma. In study II the group of 6–7-year-olds had respiratory symptoms significantly more often than 13–14-year-olds ($p < 0.001$). Boys more often had a history of wheezing ($p = 0.001$), wheeze during the previous 12 months ($p = 0.01$) and an asthma diagnosis at the age of 6–7 years ($p = 0.002$) than girls, but girls had more respiratory symptoms than boys at the age of 13–14 years ($p < 0.005$). Wheezing in the past 12 months was more common for those living in urban areas aged 6–7 years ($p = 0.04$), and there was an increase of wheeze after exercise ($p = 0.01$). For the 13–14-year-olds the risk of wheezing was higher during the previous 12 months if they lived in temperate areas ($< 20^\circ\text{C}$) and at a high altitude (> 1000 m). Living in a rural area and in a warm region ($> 20^\circ\text{C}$), increased the risk of dry cough during the previous 12 months in the group of 13–14-year-olds.

In conclusion, Costa Rica is located in the tropics with a very high humidity, an enormous variety of flora and fauna and a very high prevalence of mite and cockroach allergens, which provide important risk factors that may explain the high prevalence of asthma and asthma-related symptoms. Further possible factors, such as the change towards a more Western life style, resulting in fewer infections and parasitic diseases in the first years of life and changes in bedding material, may

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Key words: asthma; epidemiology; children; Costa Rica

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Accepted 3 March 2002

also be unresolved. Increased environmental pollution may add to the very high prevalence of asthma and related respiratory symptoms. The very extensive exposure to mites and cockroaches in bed material and in homes with poor ventilation may be an important factor, but many asthmatic children behave as non atopic, with a viral respiratory infection as a major precipitating factor.

Bronchial asthma is an important medical problem in many countries and is the most common chronic disease among school children leading to costly treatment, childhood disability and school absence. Estimates of the prevalence of asthma and allergies have varied through the years, due to a variety of different populations studied, various definitions of asthma used and also methodologies applied for the diagnosis. Many studies reported in the last years show an increasing trend in the prevalence of childhood asthma (1).

Efforts have been made to compare populations from different ethnic, geographic and socio-economic groups. The International Study of Asthma and Allergies in Childhood (ISAAC) has included comparisons between populations in different countries, permitting direct comparisons between the prevalences (2). ISAAC included 257 800 children 6–7 years of age from 38 countries and 463 801 children 13–14 years of age from 56 countries (3). There were marked variations between different centers, countries and areas around the world. In the 6–7-year-old group, the prevalence of wheezing or whistling in the chest in the previous 12 months varied from 4.1 to 32.1%. The lowest rates were found in India, Indonesia, Iran and Malaysia, and the highest rates in Australia, New Zealand and Latin America (Brazil, Costa Rica and Panama). In the 13–14-year-old group the prevalence of wheezing or whistling in the chest in the last 12 months was high in English speaking and Latin American countries as compared with other centers included in the study, ranging from 1.6% reported in Akola (India) to 36.7% in Scotland. Health surveys have disclosed different prevalences of asthma among subjects from the same country, due to differences in ethnic background, gender, geographic origin and socio-economic situation (4, 5).

Using a nationally representative sample of children between the age of 5–17 years ($n = 2682$) in 1989, we found an asthma prevalence of school children in Costa Rica of 23.4%, based on a combination of a physician's diagnosis and a parentally recalled symptom score (6). The presence of smokers in the home, living in a warm area and the occurrence of frequent upper

respiratory infections during the preceding years were found to be important risk factors (6). Further studies in Costa Rican school children (with and without asthma) showed that the most prevalent IgE antibodies in serum samples were to housedust mite allergens (*Dermatophagoides farinae*), cockroach, and dog. Increased IgE reactivity to housedust mite (*D. farinae*), cat and two molds (*Alternaria* and *Cladosporium*) allergens was significantly more prevalent among the asthmatics than the non asthmatics, who also included children with other allergic diseases (7). In house dust samples taken from the coastal and central highland regions of Costa Rica, very high levels of guanine and mite allergens were found, particularly from beds. Cockroach allergen also occurred in very high concentrations in dust samples from the houses in the coastal regions of the country (8).

The purpose of this paper is to review the prevalence of asthma and related respiratory symptoms during a period of 10 years as part of ISAAC and discuss possible explanations for the very high asthma prevalence among school children in Costa Rica.

Materials and methods

Using a nationally representative sample of school children from Costa Rica in the last 10 years (from 1989 to 1998) we performed three different studies to define the prevalence of asthma and related respiratory symptoms.

Study I: From a total of 4026 educational centers that were registered in Costa Rica in 1987 we selected 98 centers by randomly stratifying for geographic location, altitude, humidity, rural and urban regions, rain precipitation, and the size of the center.

The parents of 3000 children received a questionnaire, and 2682 (89.4%) returned it. The ages of the children were between 5 and 17 years, 52.5% were males and 47.5% females. The form included questions concerning respiratory symptoms, presence of infections, cigarette smoking habits and diagnosis of asthma.

Children were classified as asthmatics using diagnosis by a doctor in combination with the presence of four kinds of respiratory symptoms:

cough and wheeze after upper respiratory tract infections, or after exercise, as well as frequent daily and/or nightly cough, as reported by the parents in the questionnaire.

Study II: In 1995, as part of ISAAC phase I, from a total of 5000 educational centers that were registered in Costa Rica, 75 schools centers were selected by stratifying for geographic location; 1782 children from the coastal region and 4382 from the central highland area, including urban and rural locations. The sampling selection was school children aged 6–7 and 13–14 years, being representative of the country and selected at random.

ISAAC phase I used core questionnaires designed to assess the prevalence and severity of asthma and allergic disease in defined populations (9). In the general study the questionnaires were sent to 7000 subjects, 6144 (87.8%) returned the form; 2944 children aged 6–7 years and 3200 children aged 13–14 years participated in the study. The ISAAC core questionnaires were translated into Spanish, according to defined guidelines (9), including familiar terminology of the local community. The diagnosis of asthma was based on the presence of past history of recurrent wheeze during the previous 12 months.

Study III: 1500 schoolchildren aged 10 years were selected in 1998 using the same selection criteria as in 1995 (study II); 1105 (74%) returned the questionnaire (ISAAC phase I questionnaire). The questionnaires used included the same questions as in study II. The diagnosis of asthma was based on the presence of a history of wheeze during the previous 12 months.

Criteria to define the area of residence

The criteria to define the area of residence (urban/rural) were based on administrative and physical factors (urbanization, electricity, water supply, etc.) (10).

The central highland region includes those areas situated in the central provinces of Costa Rica (San José, Alajuela, Heredia and Cartago) (10), which are located on the central highland plateau of the country, with a temperate climate. The Atlantic and Pacific coasts have a tropical climate.

Statistics

The data were analyzed with the Epi info, version 6, Public Domain Software for Epidemiology and Disease Surveillance (Center for Disease Control, Epidemiology Program, Atlanta, GA, USA) and the SPSS Package.

The statistical analyses comprised frequencies, means and Odd's ratio (OR) calculations and the chi-squared test using Yates continuity correction. Comparison of proportions was using the chi-squared test.

Results

The prevalence of asthma and related respiratory symptoms among school children in studies I, II and III

As shown in Fig. 1, a very high prevalence of history of wheeze and asthma diagnosis was found in the three groups of school children sampled from 1989 to 1998. Wheezing in the past was reported in 46.8% of the children in study I, and in 42.9% in study II ($p = 0.001$). Comparing study I and study III (45.1%), no significant difference was found.

The prevalence of asthma reported in the first study (23.4%), using a physician's diagnosis and a parentally recalled symptom score was lower as compared with the prevalence of wheeze in the previous 12 months resulting from the ISAAC studies, 27.7% in 1995 ($p < 0.001$) and 27.1% in 1998 ($p = 0.01$) (Fig. 1).

The physician's diagnosis of asthma increased from study I (1989) at 23% to 23.1% in 1995 in study II ($p = \text{NS}$) to 27.1% in 1998 in study III ($p = 0.04$, comparing the results of study II with study III).

Comparisons between the two age groups of school children in study II

Wheezing or whistling in the chest at any time in the past were more common among the 6–7-year-old children than the 13–14-year-olds ($p < 0.0001$) (Table 1). The prevalence of

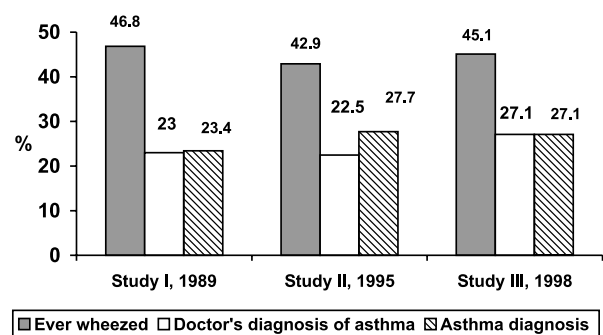


Fig. 1. Asthma and related respiratory symptoms in percentages, comparing studies I, II and III. Asthma diagnosis in study I was made according to: a combination of physician's diagnosis and a parentally recalled symptom score; studies II and III: a history of wheezing in the last 12 months according to the ISAAC protocol.

Prevalence of asthma in Costa Rican school children

Table 1. Asthma and related symptoms in percentages: comparison between two age groups. Study II (1995), according to the ISAAC protocol

| | 6–7 years n = 2944 | 13–14 years n = 3200 | p | Odds ratio | Total n = 6144 |
|---------------------------------|-----------------------|-------------------------|---------|---------------|-------------------|
| Ever wheezed | 48.8 | 37.6 | <0.0001 | 1.62 | 42.9 |
| Wheeze last 12 months | 32.1 | 23.7 | <0.0001 | 1.36 | 27.7 |
| Physician's diagnosis of asthma | 26.9 | 18.5 | <0.001 | 1.68 | 22.5 |
| Number of attacks/year | | | | | |
| None | 4.7 | 6.3 | 0.005 | – | 5.5 |
| 1–3 | 72.1 | 71.2 | NS | – | 71.7 |
| 4–12 | 17.9 | 15.4 | NS | 1.2 | 16.7 |
| >12 | 5.3 | 7.2 | NS | 0.73 | 6.1 |
| Disturbed sleep | | | | | |
| Never | 17.2 | 36.5 | <0.0001 | – | 26.9 |
| < 1 night/week | 67.1 | 48.8 | <0.0001 | 2.14 | 58.0 |
| > 1 night/week | 15.7 | 14.7 | NS | – | 15.2 |
| Wheezing limits speech | 35.9 | 42.2 | 0.07 | 0.84 | 39.1 |
| Wheezing chest after exercise | 44.9 | 59.8 | <0.0001 | 0.51 | 52.4 |
| Dry cough in last 12 months | 40.8 | 31.8 | <0.0001 | 1.47 | 36.3 |

NS = Not significant.

wheezing during the previous 12 months was higher in the younger group than the older group ($p < 0.0001$). A physician's diagnosis of asthma was more common in the younger than in the older group ($p < 0.001$). The severity of asthma symptoms showed a different pattern between the two age groups. On average, sleep disturbance due to wheezing in the last 12 months was more common in the 6–7-year-old group ($p < 0.0001$), but the number of attacks of wheezing in the last 12 months was similar in both groups.

Wheezing during or after exercise was reported more frequently in the older group (24.9%) than in the younger (17.4%, $p < 0.0001$, OR 0.64, 95% CI 0.56–0.73). Wheezing after exercise in patients with asthma according to a physician's diagnosis was present in 48% of the younger group, as compared to 53.6% in the older children ($p < 0.04$, OR 0.8, 95% CI 0.64–1). Those children with a history of wheeze in the last 12 months had wheezing after exercise in 44.9% of the younger group, compared with 59.8% of the older group ($p < 0.0001$, OR 0.51, 95% CI 0.45–0.67).

Asthma and related respiratory symptoms according to gender

The gender and age of the children were associated with different risks of school age asthma and related respiratory symptoms. Table 2 shows that in the 6–7-year-old group, wheezing or whistling in the chest at any time in the past ($p = 0.001$), history of wheeze in the last 12 months ($p = 0.01$), asthma diagnosis by a physician ($p = 0.002$), wheezing chest after exercise ($p = 0.003$) and a history of cough in the last

12 months ($p = 0.02$) were more common in males than females. In the older group (13–14 years old), asthma-related respiratory symptoms were more prevalent in females than males (had ever wheezed 40.5%/35.6%, $p = 0.005$; wheeze in the last 12 months 26.2%/21.6%, $p = 0.003$; dry cough, 36.2%/19.1%, $p < 0.001$), except for the asthma diagnosis by a physician.

The female group had more attacks of wheezing in the last 12 months than the males ($p = 0.02$). On average, sleep disturbance due to wheezing in the last 12 months was more common in females in the 13–14-year-old group ($p < 0.005$).

Occurrence of asthma according to the area of residence

The younger group living in urban areas had more wheezing episodes during the previous 12 months than those living in rural areas ($p = 0.04$).

Children aged 13–14 years, living in rural areas (34.6%) had more often a history of dry cough during the last 12 months than those children from urban areas (30.2%) ($p = 0.03$).

The older group, living in a temperate climate ($< 20^\circ\text{C}$) ($p = 0.02$) and at a high altitude (> 1000 meters) ($p = 0.02$) had a more frequent history of wheezing than those living in warmer areas ($> 20^\circ\text{C}$) and at lower altitudes (< 1000 meters) ($p = 0.02$).

The older group of children living in areas with a temperature $\geq 20^\circ\text{C}$ (33.1%) had more dry cough in the past year than those living in temperate regions (29.3%) ($p = 0.02$).

Table 2. Asthma and related symptoms in percentages: comparison between gender in two age groups. Study II (1995), based on the ISAAC protocol

| | 6–7 years | | | 13–14 years | | |
|---------------------------------|-----------|--------|--------|-------------|--------|--------|
| | Male | Female | p | Male | Female | p |
| Ever wheezed | 53.5 | 46.6 | 0.001 | 35.6 | 40.5 | 0.005 |
| Wheeze last 12 months | 35.3 | 30.7 | 0.01 | 21.6 | 26.2 | 0.003 |
| Physician's diagnosis of asthma | 30.6 | 25.3 | 0.002 | 18.7 | 18.5 | NS |
| Number of attacks/year | | | | | | |
| None | 5.2 | 5.0 | NS | 6.6 | 0.5 | 0.05 |
| 1–3 | 23.8 | 22.4 | NS | 15.2 | 18.6 | 0.01 |
| 4–12 | 6.4 | 5.0 | NS | 2.8 | 4.3 | 0.02 |
| >12 | 1.9 | 1.4 | NS | 2.0 | 1.5 | NS |
| Disturbed sleep | | | | | | |
| Never | 9.6 | 6.9 | 0.0002 | 14.0 | 12.9 | NS |
| < 1 night/week | 21.4 | 22.7 | NS | 10.3 | 11.8 | NS |
| > 1 night/week | 5.2 | 4.7 | NS | 2.7 | 4.6 | 0.005 |
| Wheezing limits speech | 11.5 | 11.1 | NS | 8.5 | 11.5 | 0.004 |
| Wheezing chest after exercise | 18.1 | 14.1 | 0.003 | 20.3 | 27.6 | <0.001 |
| Dry cough in last 12 months | 42.9 | 38.5 | 0.02 | 19.1 | 36.2 | <0.001 |

The prevalence of a history of wheeze, wheezing during the last 12 months and doctor's diagnosis of asthma was similar in the three different areas of residence (central highland and the two coasts) (Table 3) ($p = \text{NS}$).

Children living at the coast (Pacific: 83.4%, Atlantic: 77.0%) had more wheeze after exercise than those living in the central highland area (70.5%, $p < 0.001$), but wheezing after exercise was more common along the Pacific coast (83.4%) than along the Atlantic coast (77.0%) ($p = 0.01$). Wheezy chest after exercise was found more often on the Pacific than the Atlantic coast ($p = 0.01$). Other respiratory symptoms such as dry cough in the previous 12 months were found more frequently in the coastal (Pacific: 37.5%, Atlantic: 41.6%) than in the central highland areas (32.5%) ($p < 0.001$). No

significant difference was found between the two coastal areas ($p = \text{NS}$) (Table 3).

Discussion

Asthma is a heterogeneous condition with a complex genetic background (11–16, 17) that interacts with several different risk factors, such as atopy, environment, cigarette exposure, respiratory infections, food, changes in the intestinal flora and other factors, and is expressed in different ways (18–22). In recent decades several studies have been performed in children addressing the increase in the prevalence of wheeze and asthma (1, 23–28).

Considerable variation in the prevalence of childhood asthma has been shown in different studies and regions (2, 4, 29). These differences may be attributable to variable diagnostic criteria, methodologies used, problems in defining childhood asthma and confusion as to the interpretation of symptoms like cough and wheezing, mainly in early childhood (30, 31). Data from recent international comparisons of childhood asthma and respiratory related symptoms, using identical study instruments, as in ISAAC, show a real variation in the prevalence of the disease.

Our epidemiological data from three different studies indicate a very high prevalence of asthma and related respiratory symptoms in the school children of Costa Rica, and this prevalence seems to increase comparing the study I (1989) data with that from studies II (1995) and III (1998). Asthma diagnosis by a physician increased significantly from the first (23%) and second studies

Table 3. Respiratory symptoms in percentages according to area of residence in study II (1995), using the ISAAC protocol. Age 6–7 and 13–14 years (total group, $n = 6144$). Central highland ($n = 5145$), coastal: Pacific ($n = 713$), Atlantic ($n = 286$)

| | Central highland (A) | Pacific (B) | Atlantic (C) | p |
|---------------------------------|----------------------|-------------|--------------|-----------------------------------------|
| Ever wheezed | 42.8 | 42.4 | 40.7 | NS |
| Wheeze last 12 months | 27.9 | 27.0 | 27.8 | NS |
| Physician's diagnosis of asthma | 23.2 | 21.1 | 20.6 | NS |
| Wheezy chest after exercise | 70.5 | 83.4 | 77.0 | A/B < 0.001 A/C = 0.01 B/C = 0.01 |
| Dry cough in last 12 months | 32.7 | 37.5 | 41.6 | A/B = 0.01 A/C = 0.001 B/C = NS |

Significance = p .

(23.1%) to 27.1% in the third study. This increment could be a real increase in asthma prevalence or possibly be due to better awareness about asthma after our information campaign. This very high prevalence is similar to that of certain English speaking countries (United Kingdom, Australia, New Zealand and North America) (2).

The difficulty of finding a definition of asthma that it is applicable in childhood, reflects not only the lack of a single biological marker or clinical test for asthma, but also shows that this heterogeneous condition may have variable expressions. Our criteria for making the diagnosis of asthma in study I, before the start of ISAAC, was based on a physician's diagnosis and a symptom score. It led to a reasonably good correlation with the presence of wheezing episodes during the previous 12 months, used as one of the main components in the ISAAC questionnaires.

The presence of wheezing in some non-allergic individuals may also be an expression of the disease, because some of these patients with low IgE antibodies respond to bronchodilators. The high prevalence of atopic disease, particularly asthma in children of parents without a family history of atopic disease, suggests that with the drastic increase in asthma prevalence, children without an obvious genetic predisposition are also capable of acquiring asthma (32).

Some respiratory symptoms reached a prevalence of 40% in Costa Rica, such as history of wheeze in the three studies. Although it is well known that viral infections can precipitate wheezing episodes, the evidence for their role in causation of asthma remains uncertain (33–35). An increased prevalence of cough and wheezing has been shown 5–10 years after an attack of bronchiolitis diagnosed clinically or by viral isolation (36–38). Strong evidence demonstrates that lower respiratory tract infections in early life are predominantly associated with wheezing respiratory illness (39). Rhinovirus has been described as the major virus type in mild, as well as severe respiratory illnesses in children of all age groups, but particularly over 1 year of age (40). It is clear that viral infections, mainly those related to the upper respiratory tract, aeroallergen exposures, weather, and temperature changes can trigger acute exacerbations of asthma. These observations apply to a tropical country like Costa Rica, with two seasons (dry and rainy). Upper respiratory infections and asthma are more common during the wet season and the hospital admission rate for asthma increases. These findings suggest that many of the asthma-

tic children probably do not have an allergic background, but rather they behave as non atopics, with a very clear triggering factor of upper respiratory tract viral infections.

Our findings show that asthma and respiratory related symptoms were more prevalent in males than females in the younger group, but in the older group respiratory symptoms were more frequent in females than males. These findings agree with other studies, showing that asthma in early childhood is predominantly a male disease (41–43). After puberty asthma and related symptoms are more common in females. These differences may be attributable in early childhood to mechanical factors in males, such as the smaller size of the bronchi, whereas at puberty hormonal factors may influence airway inflammation in girls (42, 43).

There is some evidence that asthma and atopic diseases are less common in rural areas in developing countries and that in such countries living conditions, parasitic infestations, environmental factors and genetic influences may differ from developed societies (1), but some developed societies also present the same situation like Sweden (44), showing that children in rural areas in families working with hay had less allergy to hay than city children. The ISAAC investigations found that some areas in countries with a high parasitic load and poverty, like Brazil and Peru, had a high prevalence of asthma and related respiratory symptoms (2).

Many investigators suggest that a Western lifestyle is associated with a high prevalence of childhood allergy (29, 44, 45). Costa Rica, which has been considered a transitional society but is now included among the 50 developed countries, has an infant mortality similar to that of some of the Western societies and deals with chronic diseases like asthma as in developed countries.

It is well known that the amount of mites and Der p 1 allergen is higher in bed dust than in bedroom floor dust (8). Until some 20 years ago Costa Ricans used mattresses made of straw [hay or dry grass], which were taken out and exposed to the sun weekly and beaten. These mattresses did not last very long and people exchanged them often. Later on, mattresses made of rubber foam or other synthetic materials became very common. Samples of dust taken from mattresses of Costa Rican homes showed very high concentrations of Der p 1 in all types of mattresses, but higher concentrations of Der p 1 in the foam mattresses than in straw or hay mattresses (46). This could be an important cause and possibly a preventable one of the very high attack rate of asthma in Costa Rica.

An average yearly outside temperature above 25°C was in our first report found to be an important risk factor. The reason for this is unclear and may relate to the fact that the number of upper respiratory infections per year was significantly higher in the warmer areas, not because it was warmer, but the families in those coastal regions at that time were poorer and lived in more crowded and poorer conditions. This situation changed in studies II and III, where living in warmer places did not increase the prevalence of wheeze or asthma diagnosis, except for the presence of dry cough in the previous 12 months.

The younger group of school children living in urban areas had wheezing more often in the last 12 months than the older group, probably related to more indoor exposure to allergens.

In study II the diagnosis of asthma and related respiratory symptoms were more prevalent in the 6–7-year-olds compared with the 13–14-year-olds, as also reported in other studies (2). The age of the children was associated with an increased risk of history of wheezing and wheeze during the last 12 months. The younger group reported more wheezing episodes than the older group of school children (13–14-year-olds). This observation may be partially explained by children at this age having more upper respiratory infections triggering the wheezing episodes.

Wheezing after exercise was more prevalent among the 13–14-year-old children as compared with the 6–7-year-olds. This difference could be due to children of this age exercising more, or because their asthma worsens or parents underestimate the presence of exercise induced asthma in the 6–7-year-old group. This is an important observation, because sport activities are very common in this age group and our national campaign on asthma focuses on the importance of preventing exercise-induced asthma, by doing warming up before the exercise, but also by using preventive medicines.

Our recent studies suggest that the high prevalence of asthma in Costa Rica is probably not due to a changed intestinal bacterial flora in early life (47) as has been considered important in some countries like Sweden (22).

Costa Rica is located in the tropics with a very high humidity in some areas and with an enormous variety in flora and fauna which may be important risk factors for asthma. However, the change to rubber foam mattresses with very high concentrations of mites and cockroaches, may play a major role for the frequent appearance of asthmatic symptoms in Costa Rica (29). Reduction of exposure to mites and other bed

allergens, elimination of tobacco smoke from families and public places, reduction in inner city pollution are important measures in the prevention and management of bronchial asthma in Costa Rica. Investigations that at the moment are in progress in Costa Rica (ISAAC phase II) with measurements of IgE, skin test and lung function will give us more accurate data on the health status of the children.

Acknowledgments

This study was supported by a grant from SAREC (Swedish Agency for Research Cooperation with Developing Countries). The Ethic's Committees of the National Children's Hospital, San Jose, Costa Rica and of Sahlgrenska University Hospital, Göteborg, Sweden, approved the project.

The skillful technical assistance of Ines Gutierrez (Costa Rica) and students from the University of Costa Rica is gratefully acknowledged.

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