Risk factors for asthma in urban Ghana

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Background: Asthma is increasing in prevalence and severity in Africa. Previous studies have suggested that the prevalence of atopy in West Africa was low.
Objective: We sought to investigate the risk factors for asthma in Ghanaian school children.
Methods: Fifty children (age range, 9-16 years) with a physician diagnosis of asthma and asthma symptoms within the previous 12 months and 50 age- and sex-matched healthy control subjects were randomly selected and evaluated by means of questionnaire, skin testing, total and specific IgE measurements, and allergen level measurements from bed dust samples (mite, cat, dog, and cockroach).
Results: Asthmatic children were exposed to higher levels of mite allergens than were control children (geometric mean, 19 μg/g [95% CI, 13.6-26.5] vs 11.2 μg/g [7.4-15.7]; $P < .05$). Cat and dog allergen levels were low. There was a marked dissociation between skin test responses and the presence of specific IgE to cat and dog (CAP method). However, 84% of subjects with positive cat dander–specific IgE levels in cat CAP tests and negative skin test responses did not have Fel d 1–specific IgE (chimeric ELISA). In the univariate analysis significant associations with the patient group were found for sensitization to mite (odds ratio [OR], 9.3; 95% CI, 3.7-23.4) and cockroach (OR, 3.9; 95% CI, 1.3-11.6), inner-city residence (OR, 3.5; 95% CI, 1.4-8.9), asthma in family member (OR, 3.5; 95% CI, 1.4-9.0), low (<5) position in sibship (OR, 3.6; 95% CI, 1.2-11), presence of smoker in home (OR, 3.7; 95% CI, 1.2-11.9), small household size (OR, 0.57; 95% CI, 0.35-0.93), and use of electricity as domestic fuel (OR, 0.34; 95% CI, 0.12-0.97). In the multivariate analysis sensitization to mites remained the strongest risk factor associated with the asthmatic group (OR, 10.4; 95% CI, 3.5-30.9). The other significant associations were inner-city residence (OR, 4.8; 95% CI, 1.5-5.2), sensitization to cockroach (OR, 4.9; 95% CI, 1.3-18.6), and position in sibship of less than 5 (OR, 6.3; 95% CI, 1.3-29.4).
Conclusion: Sensitization to dust mite and cockroach allergens, inner-city residence, and low position in sibship were independent risk factors for asthma in Ghanaian children. (J Allergy Clin Immunol 2001;108:363-8.)

Key words: *Asthma, risk factors, allergens, Africa*

Abbreviation used
OR: Odds ratio

There are very few studies on asthma in Africa compared with the huge body of information from the developed countries. Most African studies conducted within the last 3 decades were hospital based and involved a predominantly adult population. Nevertheless, the results of epidemiologic studies from Africa have shown important differences compared with those from the industrialized countries. The prevalence of asthma in Africa has been low compared with that in developed countries, but it is probably increasing.[1-3]

Early studies in the 1970s stressed the late onset of asthma, usually in the second decade of life.[1-3] However, more recent studies suggest that substantial numbers of patients experience the first attack before the age of 2 years and that the prevalence of exercise-induced bronchospasm is in the range of 5% to 10.5% in schoolchildren.[4-7] The prevalence of asthma in tropical Africa may be changing in parallel with the social and economic development that has occurred in the last few decades. However, there is very little information on risk factors. Atopy, which is a major risk factor for asthma in the industrialized countries, seemed historically to be of low prevalence in sub-Saharan Africa.[8,9] This led to the suggestion that factors precipitating asthmatic attacks in tropical Africa were apparently nonallergic, such as irritants or climatic change.[8]

Urban living seems to be a substantial risk factor. We have previously reported that the prevalence of exercise-induced bronchospasm was twice as common in a rich urban population in Ghana compared with children from poor urban and rural communities,[5] and this has also been seen in Zimbabwe[6] and Kenya.[7] In the more developed South Africa, the risk factors for asthma are similar to those in industrialized Western countries (eg, hay fever, eczema, parental asthma, absence of paternal income, maternal smoking in pregnancy, and presence of household smokers).[10]

The aim of this study was to investigate the risk factors for childhood asthma in urban Ghana in a case-control study.

METHODS

The study was carried out in Kumasi, the second largest city in Ghana (population of approximately 1 million). The entire city is crowded, with light industry and considerable motor-vehicle pollu-

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Supported by the Tropical Health and Education Trust and South Manchester University Hospitals NHS Trust Endowment Trust.
Received for publication December 14, 2000; revised May 11, 2001; accepted for publication May 17, 2001.
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0091-6749/2001 $35.00 + 0 **1/81/117464**
doi:10.1067/mai.2001.117464

tion. A random sample of cases (children with asthma between the ages of 8 and 17 years) was recruited into the study from the Paediatric Asthma Clinic, Department of Child Health, Komfo Anokye Teaching Hospital (the only tertiary referral center in the area) if the following criteria were met: physician diagnosis of asthma; use of anti-asthma medication; and presence of asthma symptoms (wheeze, cough, or both) within 12 months before the study.

For each patient, 1 age- and sex-matched control subject without respiratory symptoms (screened by means of an interviewer-administered questionnaire) was randomly selected from a local school within 2 weeks of enrolling a patient, and social and environmental variables were matched with the general population. The study was approved by the Komfo Anokye Hospital/Ministry of Health Ethical Committee and the Ghana Education Service. All participants underwent the following: skin prick testing; collection of stool samples; home visit for the collection of dust samples; and interviewer-administered standard respiratory questionnaire and questionnaires on social and environmental characteristics (ATS-DLD-78 questionnaire for children)

Skin tests were performed by using the standard prick method on the volar surface of the forearm with the standardized extracts of 12 allergens (*Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, cat, dog, cockroach, *Candida albicans*, *Aspergillus flavus*, *Alternaria* species, pine, maize, mouse, and grass mix) and a negative and positive (histamine dihydrochloride, 10 mg/mL) control (Bayer Corporation, Elkahrt, Ind). A wheal response at least 3 mm in diameter larger than that produced by the negative control was regarded as a positive response. The same trained investigator performed all skin tests.

Specific serum IgE concentration to 5 allergens (*D pteronyssinus*, *Blomia tropicalis*, cat, dog, and cockroach) was determined by using the CAP-RAST FEIA (Pharmacia-Upjohn, Upsala, Sweden), and sensitization was defined as a concentration of greater than 0.35 kU/L of the specific allergen, which is in line with previous studies.[11]

Dust samples were collected from beds of the subjects during a home visit. In 4 homes where a power supply was not available, subjects were asked to bring their bedding (floor mat, blanket, and pillows) to the hospital for samples to be taken. Dust collection was done over a 1-m^2 area of bedding for 2 minutes with a vacuum cleaner (airflow, 45 L/s) adapted to collect the sample onto a 100-cm^2 sheet of bed linen supported by a dust trap. Dust was sieved through a 355-μm diameter mesh screen (Endecotts Ltd, London, United Kingdom) to obtain fine dust samples. One hundred milligrams of fine dust was extracted with 2 mL of borate-buffered saline solution with 0.1% Tween-20, pH 8.0. House dust mite (Der p 1 and Der f 1), dog (Can f 1), cat (Fel d 1), and cockroach (Bla g 2) allergens were assayed with mAb-based ELISAs, as previously described.[12-14]

The participants were given stool-specimen bottles and asked to collect a fresh stool sample. The presence of parasites was determined on a wet film (iodine preparation), and more detailed analysis of the concentration of cysts and eggs was performed with Formol-Ether Sedimentation.[15] The Stolls method was used for the quantitative estimation of ova in feces.

Initially, risk factors were assessed by means of univariate analysis to see how each potential explanatory variable affected the probability of being asthmatic. Allergen exposure data were initially analyzed as continuous variables. In addition, allergen levels were categorized by using the cut-off points previously suggested as significant (2 and 10 μg/g Der p 1, 8 μg/g Fel d 1, 10 μg/g Can f 1, and 0.8 μg/g Bla g 2). Variables were then tested in a forward stepwise multivariate analysis combining the relevant variables to control for the effect of each explanatory variable on the other variables studied. Factors that were associated with asthma group in the univariate analysis at a P value of less than .1 were examined in multivariate regression analysis. The size of the effect of each of the risk factors was measured by using the odds ratios (ORs) and 95% CIs. Data were analyzed with the Statistical Package for Social Sciences (SPSS) software, version 8.0.

RESULTS

A total of 138 children were approached to recruit 100 participants matched by age and sex who agreed to take part in the study. Demographics of the studied population are presented in Table I. Of 46 patients with reliable data on the age of onset of asthma, 38% had the onset of symptoms between the ages of 0 and 4 years (in 28% within the first year of life), 30% between 5 and 8 years, 28% between 9 and 12 years, and 4% between 13 and 16 years of age. One child had severe asthma (symptoms every day), 9 had mild-to-moderate asthma (symptomatic more than once a week), and 40 had mild asthma (only occasional symptoms). The prevalence of eczema, allergic rhinitis, and other allergies in the whole group was 16%, 63%, and 23%, respectively.

Rhinitis was significantly more common among asthmatic subjects (76%) than among nonasthmatic subjects (48%; OR, 3.2; 95% CI, 1.4-7.4; $P < .01$). The prevalence of eczema was low, and there was no difference in this prevalence between asthmatic and nonasthmatic subjects.

Atopic status assessed with skin tests and specific serum IgE measurements

The prevalence of positive skin test responses was 80% (40/50) among asthmatic children versus 30% (15/50) among nonasthmatic children. The most prevalent sensitizations in all subjects were to *D farinae* (42%), *D pteronyssinus* (41%), and cockroach (20%). Positive skin test responses to grass, mouse, and *C albicans* allergens were much less common (<10%). Multiple sensitization to allergens was predominantly a feature of asthmatic children: 68% of asthmatic children were sensitized to 2 or more allergens compared with 20% of control subjects.

Total serum IgE was significantly higher in asthmatic subjects compared with control subjects (mean difference, 5.1-fold; 95% CI, 3.2- to 8.0-fold; $P < .0001$, Table I). There was a good correlation between skin prick test positivity and the presence of detectable specific IgE levels in CAP tests in the case of dust mite and cockroach allergen but not for cat and dog. Thirty-one children who had negative skin test responses to cat had detectable cat dander–specific IgE levels on cat CAP testing. Similarly, although none of the children had positive skin test responses to dog allergen, dog-specific IgE on dog CAP testing was detectable in 38 subjects. Total IgE was below 1500 kAU/L in all of these subjects. Measurement of major allergen content (Fel d 1 and Can f 1 ELISA) confirmed the high potency of the skin testing reagents.

To address the apparent dissociation between skin test data and cat dander–specific IgE levels, we determined the level of Fel d 1–specific IgE by using a chimeric ELISA, as previously described (lower detection limit

1.5 ng/mL).[16] The results of the chimeric ELISA were as follows:

- Both subjects with positive cat dander–specific IgE levels on cat CAP testing and positive skin test responses to cat had measurable Fel d 1–specific IgE levels (1.8 and 800 ng/mL; ie, both of these individuals were allergic to cat).
- Of 30 of 31 subjects with negative skin test responses and positive cat CAP test results with sufficient serum sample for the analysis, only 5 had detectable levels of Fel d 1–specific IgE, whereas it was below the detection limit in all other 25 serum samples.
- None of the 31 subjects with negative skin test responses and negative cat CAP test results had Fel d 1–specific IgE.

Allergen levels in homes

Table II shows the mean levels of various allergens in dust samples from beds of children in the study. In the analysis of dust mite allergen levels, the results of the 2 dust mite assays (Der p 1 and Der f 1) were added and expressed in terms of total group 1 (Der 1) allergen. Ninety-seven percent of participants had dust mite allergen levels above the proposed threshold for sensitization (2 μg/g), and in 59% of participants, the levels were above 10 μg/g. Total mite allergen levels (Der 1) were significantly higher among asthmatic than among control subjects (geometric mean, 19 μg of Der 1/g [95% CI, 13.6-26.5] vs 11.2 μg of Der 1/g [7.4-15.7]; $P < .05$ for patients and control subjects, respectively; Table II). Levels of pet allergens in these 100 Ghanaian homes were very low.

Univariate analysis of the risk factors for asthma

The results of the univariate analysis are presented in Table III. The asthmatic group was significantly associated with the following: sensitization to dust mite and cockroach allergens but not to cat, dog, *Alternaria* species, and grass; increasing levels of mite allergens and being exposed to greater than 10 μg/g Der 1; a parental history of asthma, second-degree relatives with asthma, and asthma in the family (first- or second-degree relatives); living in the inner-city area (with no difference between the 2 groups with regard to the type of house or the presence of carpets); the presence of a smoker in the home; and low position in sibship (<5).

The highest position in the sibship among the group of children studied was 10. Three subjects were excluded from the analysis because the position in sibship could not be determined accurately. The categorization of birth order into groups of up to 4 and 5 or more was made on the basis of census data showing that most families in urban Ghana have 4 to 6 children, as opposed to a figure of 9 to 10 in rural families.

Asthma group was significantly and inversely associated with the following: living in small households; use of electricity for cooking at home; and dog ownership.

The size of the household was defined as the number of persons eating from the same cooking pot, which ranged from 3 to more than 20. Household sizes were classified as small (≤9) or large (≥10) for analysis. The types of fuel used for cooking in homes were charcoal, firewood, liquefied petroleum gas, electricity, and kerosene, and most of the households used a combination of different types of fuel. A total of 35% of subjects reported keeping dogs in their homes: 36% had cats and 2% had parrots. Forty-nine percent of participants did not keep any pets at home. The keeping of cats was similar in homes of asthmatic and nonasthmatic subjects. The presence of pets of any kind in homes was very similar between asthmatic and nonasthmatic subjects (50% [25/50] vs 52% [26/50], $P > .1$). A total of 21% of subjects kept livestock (mainly goats, sheep, guinea pigs, rabbits, and poultry) in their compound, with no difference between the groups.

All subjects had stool samples tested. Helminths were found in only 5 stool samples (*Ascaris lumbricoides* in 4 and *Schistosoma mansoni* in 1). However, 88% of patients and 72% of control subjects had been prescribed treatment for parasites within 6 months before enrollment. Because of the very low number of positive samples, no further analysis was performed.

Multivariate analysis

Significant factors from the univariate analysis were considered in the multivariate regression analysis. Atopic status was determined by using the skin testing data. Sensitization to dust mites remained the strongest independent risk factor associated with patient group (OR, 10.4; 95% CI, 3.5-30.9; $P < .0001$). The other significant asso-

TABLE I. Demographic data of the study population

	Control subjects	Asthmatic subjects
Age (y)	13.3 ± 1.5*	13.3 ± 2.3*
Girls25/50	25/50	
Type of house		
Bungalow	17/50 (34%)	21/50 (42%)
Flat	24/50 (48%)	13/50 (26%)
Compound house	9/50 (18%)	16/50 (32%)
Carpet at home	43/50 (86%)	48/50 (96%)
Birth order		
1	11/48	17/49
2	10/48	7/49
3	7/48	10/49
4	6/48	10/49
5	5/48	3/49
6	7/48	0/49
7	1/48	1/49
8	0/48	1/49
10	1/48	0/49
Pet ownership		
Cat	15/50 (30%)	21/50 (42%)
Dog	23/50 (46%)	12/50 (24%)
Livestock at home	12/50 (24%)	9/50 (18%)
Total serum IgE (kU/L)	96 (1.6-1023)†	485 (27.5-2803)†

*Mean ± SD.
†Geometric mean (range).

TABLE II. House dust mite, cat, dog, and cockroach allergen levels in homes in Ghana (GM [95% CI])

	Whole group (n = 96)	Patients (n = 50)	Control subjects (n = 46)	Significance (*P* value)
Der p 1 (μg/g)	13.3 (10.1-17.6)	17 (11.9-24.3)	10.2 (6.7-15.7)	.07
Der 1* (μg/g)	14.7 (11.3-19.2)	19 (13.6-26.5)	11.2 (7.4 -16.8)	<.05
Can f 1 (μg/g)	0.5 (0.4-0.6)	0.5 (0.4-0.6)	0.5 (0.4-0.6)	.97
Fel d 1 (μg/g)	0.5 (0.4-0.6)	0.5 (0.3-0.6)	0.5 (0.4-0.6)	.86
Bla g 2 (μg/g)	0.6 (0.5-0.7)	0.6 (0.5-0.8)	0.5 (0.4-0.6)	.16

*The results of the 2 dust mite assays (Der p 1 and Der f 1) were added and expressed in terms of total group 1 (Der 1) allergen.

TABLE III. Univariate analysis of potential risk factors in patient groups

	Control subjects	Asthmatic subjects	OR (95% CI)	Significance (*P* value)
Sensitivity to allergen (skin prick testing)				
Any allergen (atopy)	15 (30%)	40 (80%)	9.3 (3.7-23.4)	<.0001
Dermatophagoides farinae	9 (18%)	33 (66%)	8.8 (3.5-22.4)	<.0001
Dermatophagoides pteronyssinus	10 (20%)	31 (62%)	6.5 (2.7-16)	<.0001
Any house dust mite	10 (20%)	35 (70%)	9.3 (3.7-23.4)	<.0001
Cockroach	5 (10%)	15 (30%)	3.9 (1.3-11.6)	.01
Cat	1 (2%)	2 (4%)		NS
Dog	1 (2%)	0 (0%)		NS
Alternaria species	1 (2%)	2 (4%)		NS
Aspergillus species	0 (0%)	2 (4%)		NS
Mixed grasses	7 (14%)	2 (4%)	0.26 (0.05-1.3)	.1
Mouse	7 (14%)	1 (2%)		NS
Pine	1 (2%)	0		NS
Corn	2 (4%)	0		NS
Sensitivity to allergen (specific serum IgE)				
Any allergen	28 (56%)	45 (90%)	8.8 (2.3-28.3)	<.0001
House dust mite	19 (38%)	42 (84%)	9.8 (3.7-26.2)	<.0001
Blomia tropicalis	15 (30%)	37 (76%)	7.2 (2.9-17.5)	<.0001
Cockroach	14 (28%)	37 (76%)	7.9 (3.2-19.4)	<.0001
Cat	13 (26%)	20 (41%)	1.9 (0.84-4.6)	.12
Dog	10 (20%)	28 (57%)	5.3 (2.2-13.0)	.0002
Family history				
Maternal asthma	2 (4%)	6 (12%)	3.3 (0.63-17.1)	NS
Paternal asthma	4 (8%)	12 (24%)	3.6 (1.1-12.3)	.04
Either parent with asthma	6 (12%)	16 (32%)	3.5 (1.2-9.8)	.02
Sibling with asthma	5 (10%)	12 (24%)	2.8 (0.92-8.8)	.07
Asthma in second-degree relative	4 (8%)	13 (26%)	4.0 (1.2-13.4)	.02
Asthma in family	8 (16%)	20 (40%)	3.5 (1.4-9.0)	.009
Environmental factors				
Inner-city residence	9 (18%)	22 (44%)	3.5 (1.4-8.9)	.002
Electricity domestic fuel	25/40 (62.5%)	34/41 (82.8%)	0.34 (0.12-0.97)	.043
Small household size	7/40 (17.5%)	18/40 (45%)	0.26 (0.09-0.72)	.007
Position in sibship (<5)	34/48 (70.8%)	44/49 (89.8%)	3.6 (1.18-11)	.02
Smoker at home	5/38 (13.2%)	13/36 (36%)	3.7 (1.2-11.9)	.025
Dog ownership	23 (46%)	12 (24%)	0.37 (0.16-0.87)	.02
Der 1 (μg/g)			2.1 (1.0-4.5)	.049
Der 1 >10 μg/g	21 (42%)	36 (72%)	3.06 (1.31-7.14)	.009

ciations were inner-city residence (OR, 4.8; 95% CI, 1.5-15.2; $P = .007$), sensitization to cockroach (OR, 4.9; 95% CI, 1.3-18.6; $P = .018$), and position in sibship of less than 5 (OR, 6.3; 95% CI, 1.3-29.4; $P < .02$).

DISCUSSION

This study is the first to investigate the risk factors associated with asthma in children in West Africa. In the univariate analysis important risk factors for childhood asthma in Ghana were atopy (defined as a positive skin test response to ≥1 allergen), exposure to tobacco smoke at home, position in sibship of less than 5, family history of asthma, and inner-city area of residence. The finding of atopy, and especially of multiple allergen sensitization, as a major risk factor for asthma in Ghanaian children is in keeping with numerous reports from developed countries but sharply contrasts with the earlier reports from West Africa, which suggested that factors responsible for symptoms of asthma were nonallergic.[3]

Twenty years ago, atopy and atopic diseases, such as allergic rhinitis and eczema, were reported to be of very low prevalence in West Africa.[8,9] In the current study none of the children had eczema on physical examination. However, allergic rhinitis was very common, particularly among asthmatic subjects, which mirrors the findings in the developed countries but contrasts with those from the developing world.

Sensitization to dust mite and cockroach allergens were the most common types of sensitization in the current study. Several studies have investigated dust mite sensitivity in Africa. In 1973, Commey and Haddock found only 33% of 40 asthmatic adults sensitized to dust mites in Accra, Ghana.[8] Warrell et al[1] in Nigeria reported a prevalence of positive skin test responses to dust mites of 45% among predominantly adult asthmatic subjects. In Rhodesia (Zimbabwe) in 1975, sensitivity to mites was found to be 36% among asthmatic subjects and 2% among nonasthmatic subjects.[9] The proportion of Ghanaian asthmatic children sensitive to dust mites in this study (>60%) is the highest reported in West Africa.

Cockroaches are a major source of indoor allergen in some parts of the world, particularly in the homes of patients of lower socioeconomic status. Sensitization to cockroach allergens is an important risk factor for asthma in urban areas in the United States,[17] in the Far East,[18] and in France.[19] Very few studies from Africa have investigated sensitization to cockroach. Fraser,[20] in 1979, reported a prevalence of cockroach sensitization of approximately 30% among 30 asthmatic subjects in Durban, South Africa. In a group of children and adults in Nigeria, a significantly higher prevalence of cockroach sensitization was reported among asthmatic subjects (32%) compared with nonasthmatic subjects (10%).[1] Similar results were found in this study of Ghanaian children.

Recent studies highlight the importance of cat and dog allergens in asthma in developed countries with a high proportion of pet ownership.[21] Pet ownership in traditional Chinese culture is rare, and asthma is not associated with pet allergy, whereas in urban Hong Kong, where pet ownership is much greater, being sensitized to animal dander represents a significant risk factor for asthma.[22] In the current study the frequency of cat ownership, dog ownership, or both, as assessed with the standard questionnaire, was comparable with that in the United Kingdom and other developed countries (approximately 50%). However, the prevalence of sensitization to cat and dog assessed by skin testing was remarkably low. Similarly, Awodetu at al[23] in Nigeria reported a prevalence of positive skin test responses to cat fur and dog hair of 13% and 12%, respectively, among asthmatic subjects aged 10 to 19 years, with none of the nonasthmatic subjects being sensitized. The current study is one of the first to measure the levels of indoor allergens in homes in Africa. Very low levels of pet allergens, which we found in homes, might explain the low prevalence of sensitization to cat and dog allergens. Although reported pet ownership was high, allergen levels in homes were low (probably because of the fact that in the Ghanaian community pets are kept predominantly outdoors).

High levels of mite allergens in the current study confirm that dust mites are abundant in Ghanaian homes. Similar levels have been reported from other regions where dust mite allergens constitute a significant risk factor for asthma.[24] In this Ghanaian study 97% of all participants had bed dust mite allergen levels exceeding the proposed threshold for sensitization of 2 μg/g dust. In the case of cockroach allergens, the minimum level of Bla g 2 recorded for the whole group was 0.1 μg/g. During home visits, we observed that the use of pile carpets in bedrooms was uncommon, but uncovered foam mattresses either on the floor or on the bed have become popular in Ghana within the last 2 to 3 decades.

We observed a considerable dissociation between skin test responses and the presence of specific IgE to cat and dog measured with the standard CAP method. It has recently been demonstrated that the use of the chimeric ELISA allowed accurate diagnosis of cat allergy.[16] The results of a chimeric ELISA for Fel d 1–specific IgE suggest that the vast majority (84%) of subjects with positive cat dander–specific IgE levels in cat CAP tests who had negative skin test responses did not react with Fel d 1. Instead, they could have reacted either specifically with different cat proteins that are present in the RAST columns but not in the skin testing solution or, much more likely, nonspecifically with nonspecific components present in the RAST columns but not in the skin testing solution. Thus any estimates of pet allergy in Africa on the basis of the use of CAP testing need to be interpreted with caution.

Inner-city residence in Africa has been associated with high asthma morbidity for reasons that are not fully understood. Features of urban areas that favor a high risk of developing asthma could include overcrowding, dampness, the presence of modern buildings, and furnishings that promote the growth of dust mites. The inner city of Kumasi is crowded and has considerable pollution from automobile fumes. However, proxy measures of crowding, such as type of housing, household size, and number of persons sharing a bed, were not significant risk factors for asthma among children in this study. Higher risk of childhood asthma among inner-city than among outer-city residents cannot be explained on the basis of allergen exposure and atopy because levels of important allergens (mite and cockroach) and the prevalence of atopy were similar between the 2 areas.

Some studies in the developed countries have found the prevalence of atopy to decline with increasing number of siblings and family size,[25] whereas others have not.[26] The association of asthma with a lower sibship position in this study is unlikely to be related to differences in number or type of infections in early life.

In conclusion, sensitization to dust mite and cockroach allergens, inner-city residence, and position in sibship of less than 5 were independent risk factors for asthma in Ghanaian children. This is similar to what is found in the developed countries but contrasts with some of the previous findings in the developing world. Indoor pollutants and allergens from pets and molds did not constitute a

significant risk. Dust mite allergens appear to be important and may be cofactors acting on a population at increasing susceptibility as the lifestyle changes.

REFERENCES

1. Warrell DA, Fawcet IW, Harrison BDW, et al. Bronchial asthma in the Nigerian Savannah Region. QJM 1975;174:325-47.
2. Abdurrahman MB, Taqi AM. Childhood bronchial asthma in Northern Nigeria. Clin Allergy 1982;12:379-84.
3. Rees PH, Gitoho F, Mitchell HS, Rees C. Some aspects of the aetiology of asthma in Nairobi with special reference to parasites and the house dust mite. East Afr Med J 1974;51:729-33.
4. Van Niekerk, CH, Wiebers EG, Shore SC, Heese HV, van Dhalkwyk DJ. Prevalence of asthma: a comparative study of urban and rural Xhosa children. Clin Allergy 1979;9:319-24.
5. Addo-Yobo EOD, Custovic A, Taggart SCO, Asafo-Agyei AP, Woodcock A. Exercise induced bronchospasm in Ghana: differences in prevalence between urban and rural schoolchildren. Thorax 1997;52:161-5.
6. Keeley DJ, Neill P, Gallivan S. Comparison of the prevalence of reversible airway obstruction in rural and urban Zimbabwean children. Thorax 1991;46:549-53.
7. Ng'ang'a LW, Odhiambo JA, Omwega MJ, et al. Exercise-induced bronchospasm: a pilot survey. East Afr Med J 1997;74:694-8.
8. Haddock DR, SI Onwuka. Skin tests in Nigeria asthmatics form the equatorial forest zone in Benin, Nigeria. Trans R Soc Trop Med Hyg 1977;71:32-4.
9. Cookson JB, Makoni G. Seasonal asthma and the house dust mite in tropical Africa. Clin Allergy 1975;5:375-80.
10. Ehrlich RI, Du-Toit D, Jordaan E, et al. Risk factors for childhood asthma and wheezing. Importance of maternal and household smoking. Am J Respir Crit Care Med 1996;154:681-8.
11. Lau S, Illi S, Sommerfeld C, et al. Early exposure to house dust mite and cat allergens and development of childhood asthma: a cohort study. Lancet 2000;356:1392-7.
12. Luczynska CM, Arruda LK, Platts-Mills TAE, Miller JD, Lopez M, Chapman MD. A two site monoclonal antibody ELISA for the quantification of the major *Dermatophagoides* spp. allergens, Der p I and Der f I. J Immunol Methods 1989;118:227-35.
13. Chapman MD, Aalberse RC, Brown MJ, Platts-Mills TAE. Monoclonal antibodies to the major feline allergen Fel d I. II: single step affinity purification of Fel d I, N terminal sequence analysis and development of a sensitive two site immunoassay to assess Fel d I exposure. J Immunol 1988;140:812-8.
14. Pollart SM, Smith TF, Morris EC, Platts-Mills TAE, Chapman MD. Environmental exposure to cockroach allergens: analysis using a monoclonal antibody-based enzyme immunoassay. J Allergy Clin Immunol 1991;87:505-10.
15. Pritchard DI, Quinnell RJ, Slater AF, et al. Epidemiology and immunology of Necator americanus infection in a community in Papua New Guines: humoral responses to excretory-secretory and cuticular collagen antigens. Parasitology 1990;100:317-26.
16. Ichikawa K, Iwasaki E, Baba M, Chapman MD. High prevalence of sensitisation to cat allergen among Japanese children with asthma, living without cats. Clin Exp Allergy 1999;29:754-61.
17. Rosenstreich DL, Eggleston P, Kattan M. et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. N Engl J Med 1997;336:1356-63.
18. Lan JL, Lee DT, Wu CH, Chang CP, Yeh CL. Cockroach hypersensitivity: preliminary study of allergic cockroach asthma in Taiwan. J Allergy Clin Immunol 1988;82:736-40.
19. de Blay F, Sanchez J, Hedelin G, et al. Dust and airborne exposure to allergens derived from cockroach *(Blatella Germanica)* in low-cost public housing in Strasbourg (France). J Allergy Clin Immunol 1997;99:107-12.
20. Fraser BN. Cockroaches in relation to bronchial asthma in the Durban area. S Afr Med J 1979;55:637-8.
21. Ingram JM, Sporik R, Rose G, Honsinger R, Chapman MD, Platts-Mills TAE. Quantitative assessment of exposure to dog (Can f 1) and cat (Fel d 1) allergens: relationship to sensitisation and asthma among children living in Los Alamos, New Mexico. J Allergy Clin Immunol 1996;96:449-56.
22. Leung R, Ho P, Lam CWK, Lai CKW. Sensitisation to inhaled allergens as a risk factor for asthma and allergic disease in Chinese population. J Allergy Clin Immunol 1997;99:594-9.
23. Awodetu AA, Oyejide CO, Ogunlesi A, Onadeko BO. Skin sensitivity patterns to inhalant allergens in Nigerian asthmatic patients. East Afr Med J 1992;69:631-5.
24. Peat JK, Tovey ER, Toelle BG, et al. House dust mite allergens: a major risk factor for childhood asthma in Australia. Am J Respir Crit Care Med 1996;152:144-6.
25. Von Mutius E, Martinez FD, Fritzsch C, Nicolai T, Reitmer P, Thiemann H-H. Skin test reactivity and number of siblings. BMJ 1994;308:692-5.
26. Rona RJ, Hughes JM, Chinn S. Association between asthma and family size between 1977 and 1994. J Epidemiol Commun Health 1999;53:15-9.