

Asthma and sensitization in a community with low indoor allergen levels and low pet-keeping frequency

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Background: Little is known about causes of asthma and sensitization in desert countries.

Objective: To investigate risk factors associated with asthma and sensitization in Kuwait.

Methods: One hundred sixty children (9-16 years) with physician-diagnosed asthma were recruited and matched (age, sex) with 303 healthy controls. Risk factors were assessed by questionnaires, determination of sensitization status (skin tests and IgE), and home allergen exposure (mite, cat, dog, cockroach; ELISA).

Results: Home allergen levels and frequency of pet ownership were very low (cat, 4.1%; dog, 1.5%). The risk of cat sensitization increased significantly among cat owners (odds ratio [OR], 3.53; 95% CI, 1.33-9.41; $P = .01$), and in children with reported contact with cats during the first year of life (OR, 2.60; 95% CI, 1.17-5.80; $P = .019$). In the multivariate analysis, maternal atopy (OR, 1.77; 95% CI, 1.13-2.75; $P = .01$) and cat ownership (OR, 3.32; 95% CI, 1.19-9.25; $P = .02$) remained significant associates of cat sensitization. Current dog ownership significantly increased the risk of sensitization to dog (OR, 6.05; 95% CI, 1.33-27.54; $P = .02$). In the multivariate analysis, dog ownership remained the only significant associate of dog sensitization (OR, 6.02; 95% CI, 1.30-27.96; $P = .02$). Sensitization to *Alternaria* was the strongest independent associate of the asthma group. Family history of asthma, history of whooping cough, current cat ownership, and breast-feeding <2 months were other significant and independent risk factors for asthma.

Conclusions: Pet ownership markedly increased the risk of sensitization to pets. Despite low allergen exposure, the pattern of childhood asthma in Kuwait follows that described in Western communities (strong association with sensitization). (J Allergy Clin Immunol 2004;114:1389-94.)

Key words: Asthma, sensitization, domestic pets, allergen exposure

Many areas of the world have had an increase in the prevalence of allergic sensitization asthma in the last several decades.¹⁻³ IgE-mediated sensitization is a strong risk factor for asthma.⁴ Allergen exposure is a prerequisite for the development of sensitization, and for dust mite and cockroach, there is a dose-response relationship between exposure and sensitization.^{5,6} However, allergen exposure does not appear to be implicated in the development of asthma.⁷ The effect of pet ownership and exposure to pet allergens on the development of sensitization and asthma is even less clear. On the basis of the currently available evidence, any association among pet ownership, sensitization, and asthma can be supported (ie, increase in risk, protection, or no effect⁸⁻¹⁰). However, most of the studies investigating the relationship between allergen exposure, pet ownership, and asthma and allergy have been performed in the areas where mites,^{5,10} or cockroaches,⁶ or domestic pets dominate sensitization.¹¹

Kuwait is a country in the Arabian Peninsula. Because of its climate and cultural avoidance of pets, it offers a unique environment to investigate these relationships. The climate is dry, with an average annual rainfall of less than 15 cm. Average summer day temperature is approximately 42°C, and the mean relative humidity ranges from 15% to 30%. These climatic conditions are not conducive for dust mite population survival. The frequency of cat and dog ownership is very low, because pet ownership is not socially acceptable. There is little vegetation in most of the country. *Prosopis juliflora* (Velvet mesquite, a perennial deciduous thorny shrub or small tree) has been planted to reclaim the desert land, and its plantations provide shelter and prevent landslides. Allergic diseases were extremely rare in Kuwait until the mid-1950s.¹² Since then, however, the prevalence seems to have increased rapidly. Within a 3-year period (1982-1985), asthma admissions among Kuwaiti children had increased from 9% to 15% of all emergency admissions.¹³ In the year 2000, the prevalence rates of wheeze ever, current wheeze, and physician-diagnosed asthma were 26%, 16%, and 15%, respectively.¹⁴

We hypothesized that the indoor allergen exposure in this area would be low, and aimed to investigate the risk

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Abbreviation used

OR: Odds ratio

factors associated with childhood asthma and allergic sensitization.

METHODS

Participants

Children with asthma, age 8 to 15 years (cases), were recruited into the study from the local allergy center (n = 92), family practices (n = 46), and pediatric asthma clinics in 3 main hospitals in Kuwait (n = 22) if all of the following criteria were met: (1) physician-diagnosed asthma, (2) asthma symptoms (wheeze, cough, or both) within the previous 12 months, and (3) use of antiasthma medication. For each case, 2 age-matched (± 2 years) and sex-matched control subjects without respiratory symptoms (confirmed by an interviewer-administered questionnaire) were randomly selected from local schools within 3 weeks of enrolling a case, and social and environmental variables were matched with the general population. The study was approved by the local ethics committee, and informed consent was obtained from all parents (and children when appropriate).

Outcomes

We ascertained housing conditions, family history, parental smoking, pet ownership, and pet contact by standard respiratory and environmental questionnaires (ISAAC¹⁵ and ATS¹⁶).

Sensitization status was determined by skin prick testing (n = 461) by using the extracts of *Dermatophagoides pteronyssinus*, cat, dog, cockroach, *Aspergillus*, *Alternaria*, *Cladosporium*, trees mix, and grass mix with negative and positive control (Bayer, Elkhart, Ind). Sensitization was defined as a weal diameter 3 mm greater than negative control.

Total and specific serum IgE (n = 430; *D pteronyssinus*, cat, dog, cockroach, *Alternaria*, Bermuda grass, *Prosopis* tree, ascaris) was measured by using the ImmunoCAP assay (Pharmacia, Uppsala, Sweden). Sensitization was defined as a concentration of allergen-specific IgE >0.35 kU/L.

Indoor allergen exposure was determined as follows. Homes were visited, and dust samples from the child's mattress and the lounge floor were collected and extracted. Mite (Der p 1 and Der f 1), cat (Fel d 1), dog (Can f 1), and cockroach (Bla g 2) allergens were assayed by using mAb-based enzyme-linked immunoassay.¹⁷⁻²⁰ A total of 420 homes were visited (7 refused a home visit; 36 supplied incomplete addresses).

Statistical analysis

To estimate the sample size, we made an assumption that asthma prevalence in Kuwaiti children was $\sim 10\%$. With a logistic regression analysis, a study of 129 cases and 262 controls has $>95\%$ power to detect an odds ratio (OR) of ≥ 2.8 at a level of significance $<.05$.

Allergen levels did not follow the normal distribution; the data are thus reported as median, range, and interquartile range, and the comparisons were performed by using the appropriate nonparametric tests (Mann-Whitney *U* test and Kruskal-Wallis test). Initially, risk factors were assessed by means of univariate analysis to see how each potential explanatory variable affected the probability of having asthma. 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 significantly associated with the asthma group in the univariate analysis were examined in multivariate regression analysis. The size of the

effect of each of the risk factors was measured by using the ORs and 95% CIs. Data were analyzed by using SPSS software (SPSS Inc, Chicago, Ill), version 10.0.

RESULTS

A total of 160 patients with asthma (117 male; mean age, 12.5 years) and 303 age-matched and sex-matched controls participated in the study (135 cases were successfully matched with 2 controls, whereas 13 had 1 matched control).

Pet ownership and indoor allergen levels

Allergen levels in the dust samples from homes were all extremely low (Table I). Der p 1 was above the detection limit of the assay in only 2 samples, and Der f 1 was detected in 9 samples. Bla g 2 levels in the dust samples were generally low.

The frequency of current pet ownership was very low (cat, 4.1% [19/463]; dog, 1.5% [7/463]). Fel d 1 was significantly higher in houses with a cat (n = 19) compared with those without a cat ($P < .001$; Table II) and in homes of children who reported contact with a cat outside the house at least once a week (n = 24) compared with children with no regular contact with a cat (n = 377; lounge floor, $P = .002$; mattress, $P = .03$; Table II). Similarly, Can f 1 was significantly higher in houses with a dog (n = 7) compared with those without a dog (lounge floor, $P = .001$; mattress, $P = .003$; Table II), but there was no difference between homes of children who reported contact with a dog outside the house at least once a week (n = 8) compared with those with no regular contact with dogs (n = 405; Table II).

Risk factors for IgE-mediated sensitization

In comparison with noncat owners with no regular contact with cats, the risk of positive skin test to cat increased in children with regular contact with cats at least once a week outside the home (OR, 1.89; 95% CI, 0.80-4.44; $P = .15$) and increased further and significantly among current cat owners (OR, 3.53; 95% CI, 1.33-9.41; $P = .01$). Reported contact with cats during the first year of life and current exposure to a high level of Fel d 1 (>8 $\mu\text{g/g}$ in mattress dust) were significant associates of a positive skin test to cat (OR, 2.60; 95% CI, 1.17-5.80; $P = .019$; and OR, 6.20; 95% CI, 1.52-25.30; $P = .01$, respectively).

The proportion of children with a positive specific IgE to cat increased from 21.0% (82/390) among noncat owners with no regular contact with cats to 37.5% (9/24) in those with regular contact with cats and 56.3% (9/16) among cat owners (P for trend, $<.001$).

To assess the independent effect of cat ownership on sensitization to cats (assessed by skin test), the adjustment for potential confounding factors (parental histories of atopy, maternal smoking, socioeconomic status, and presence of older siblings) was modeled by using multivariate logistic regression. Maternal atopy (OR, 1.77; 95% CI, 1.13-2.75; $P = .01$) and current cat ownership

TABLE I. House dust mite, cat, dog and cockroach allergens in dust samples from homes ($\mu\text{g/g}$ fine dust)

	Lounge floor		Mattress	
	Below detection limit	Median (interquartile range) [range]	Below detection limit	Median (interquartile range) [range]
Der p 1	382/383 (99.7%)	NA [0.05-0.16]	378/379 (99.7%)	NA [0.05-0.10]
Der f 1	381/383 (99.5%)	NA [0.05-10.70]	368/375 (98.1%)	NA [0.05-11.00]
Fel d 1	45/382 (11.8%)	0.16 (0.08-0.36) [0.05-700]	57/376 (15.2%)	0.14 (0.08-0.27) [0.05-410]
Can f 1	332/383 (86.7%)	NA [0.05-8.75]	316/379 (83.4%)	NA [0.05-8.00]
Bla g 2	168/381 (44.1%)	0.07 (0.05-0.26) [0.05-7.38]	196/378 (51.9%)	0.05 (0.05-0.32) [0.05-10.5]

TABLE II. Pet ownership, contact with pets, and pet allergen levels $\mu\text{g/g}$ fine dust)

	Lounge floor	Mattress
	Fel d 1, median (interquartile range) [range]	Fel d 1, median (interquartile range) [range]
Cat owner	0.63 (0.21-23.60) [0.05-700]	0.50 (0.16-3.40) [0.08-410]
Regular contact with cats outside home	0.38 (0.17-0.81) [0.05-11.60]	0.18 (0.11-0.76) [0.05-9.40]
No contact with cats	0.15 (0.08-0.30) [0.05-6.60]	0.13 (0.07-0.25) [0.05-38.20]
	Can f 1, median (interquartile range) [range]	Can f 1, median (interquartile range) [range]
Dog owner	0.16 (0.05-0.90) [0.05-8.75]	0.14 (0.05-0.52) [0.05-8.00]
Regular contact with dogs outside home	All samples below the detection limit	0.05 (0.05-0.05) [0.05-0.40]
No contact with dogs	0.05 (0.05-0.05) [0.05-8.25]	0.05 (0.05-0.05) [0.05-0.90]

remained significant associates of sensitization to cat (by using noncat owners with no regular contact with cats as a reference group, the risk of sensitization to cat increased significantly among cat owners: OR, 3.32; 95% CI, 1.19-9.25; $P = .02$). Similar data were obtained for specific IgE to cat.

Current dog ownership significantly increased the risk of sensitization to dog (skin test, OR, 6.05; 95% CI, 1.33-27.54; $P = .02$; IgE, OR, 6.91; 95% CI, 1.51-31.56; $P = .01$). In the multivariate analysis (controlling for the effect of parental history of atopy, maternal smoking, socioeconomic status, and presence of older siblings), dog ownership remained the only significant associate of sensitization to dog (skin test, OR, 6.02; 95% CI, 1.30-27.96; $P = .02$; IgE, OR, 6.76; 95% CI, 1.44-31.64; $P = .01$). Can f 1 level did not reach the level suggested as a threshold level for sensitization (10 $\mu\text{g/g}$) in any of the homes. We defined high exposure as a detectable Can f 1 in the lounge floor dust. Dog sensitization (IgE) was significantly associated with exposure to Can f 1 (OR, 2.56; 95% CI, 1.17-5.58; $P = .018$). There was no association between cat or dog ownership and sensitization to other allergens.

Cockroach sensitization (IgE) was significantly associated with exposure to high level of Bla g 2 (>2 U/g in lounge floor; OR, 3.24; 95% CI, 1.06-9.94; $P = .04$). Too few samples had detectable mite allergen to perform any exposure-sensitization analysis.

Risk factors for asthma

The significant associates of asthma group in the univariate analysis are presented in Table III. Asthma was associated with specific sensitization to a range of indoor and outdoor allergens, current cat ownership,

regular contact with cats during the first year of life, family history of asthma, exposure to environmental tobacco smoke, and a history of whooping cough. Significant protective factors in the univariate analysis were breast-feeding >2 months, day-care attendance, and sharing a bed with other family members. There was no significant difference between children with and without asthma in the levels of mite, cat, dog, and cockroach allergens. Type of heating, floor covering, air conditioning, and other housing characteristics did not differ between the groups.

Multivariate analyses

Significant factors from the univariate analysis were considered in the multivariate regression analysis. Separate analyses were performed for sensitization status determined by using skin tests (Table IV) and specific serum IgE (Table V). In both models family history of asthma, history of whooping cough and current cat ownership remained significant and independent risk factors for asthma, whereas breast-feeding >2 months was protective. For both skin tests and IgE measurement, sensitization to *Alternaria* was the strongest independent risk factor associated with patient group. Other sensitizations significantly associated with asthma group were *Cladosporium*, tree mix, cat, and dust mite (skin tests; Table IV) and *P. juliflora* (IgE; Table V).

DISCUSSION

The results of the current study suggest that the pattern of childhood asthma in Kuwait follows that already been described in Western communities, ie, that it is strongly associated with sensitization to allergens. However, the striking characteristic of this area is very low domestic

TABLE III. Univariate analysis of the risk factors for asthma

	Asthma	Control	OR (95% CI)	Significance
Maternal asthma	27 (17%)	19 (6%)	3.13 (1.70-5.74)	<.001
Paternal asthma	20 (13%)	17 (6%)	2.37 (1.27-4.40)	.006
Asthma in other family member	107 (63%)	106 (35%)	3.82 (2.55-5.74)	<.001
>20 Cigarettes smoked at home	26 (17%)	26 (9%)	1.92 (1.05-3.51)	.033
History of whooping cough	10 (6%)	3 (1%)	6.60 (1.79-24.34)	.005
Current cat ownership	14 (9%)	5 (2%)	5.82 (2.05-16.46)	.001
Contact with cats at least once a week	22 (14%)	19 (6%)	2.36 (1.23-4.50)	.009
Contact with cats during first year of life	14 (9%)	12 (4%)	2.30 (1.04-5.10)	.04
Breast feeding >2 mo	109 (69%)	238 (79%)	0.57 (0.37-0.89)	.009
Attending day care	16 (10%)	50 (17%)	0.56 (0.30-1.00)	.05
Bed sharing with other family member	8 (5%)	38 (13%)	0.37 (0.17-0.81)	.012
Skin prick tests	N = 158	N = 303		
Cat	73 (46%)	46 (15%)	4.80 (3.08-7.47)	<.001
Grass mix	58 (37%)	56 (19%)	2.60 (1.66-3.95)	<.001
Dog	55 (35%)	31 (10%)	4.69 (2.86-7.69)	<.001
<i>Aspergillus</i>	37 (24%)	12 (4%)	7.42 (3.74-14.71)	<.001
Cockroach	34 (22%)	35 (12%)	2.10 (1.25-3.52)	.005
House dust mite	31 (20%)	13 (4%)	5.45 (2.76-10.75)	<.001
Trees mix	30 (19%)	15 (5%)	4.50 (2.34-8.65)	<.001
<i>Cladosporium</i>	28 (18%)	7 (2%)	9.11 (3.88-21.38)	<.001
<i>Alternaria alternata</i>	29 (18%)	6 (2%)	11.13 (4.50-27.45)	<.001
At least 1	118 (75%)	114 (38%)	4.89 (3.19-7.50)	<.001
Specific serum IgE	N = 154	N = 285		
Bermuda grass	86 (56%)	87 (31%)	2.84 (1.89-4.25)	<.001
<i>P. juliflora</i>	67 (43%)	58 (20%)	2.98 (1.94-4.58)	<.001
Cat	59 (38%)	43 (15%)	3.46 (2.19-5.47)	<.001
<i>A. alternata</i>	54 (35%)	12 (4%)	12.16 (6.25-36.70)	<.001
House dust mite	46 (30%)	24 (8%)	4.59 (2.67-7.89)	<.001
Dog	44 (28%)	30 (11%)	3.37 (2.01-5.64)	<.001
Cockroach	44 (28%)	50 (18%)	1.86 (1.17-2.96)	.009
Ascaris	26 (17%)	22 (7%)	2.41 (1.32-4.42)	.004
At least 1	124 (80%)	133 (47%)	4.69 (2.96-7.45)	<.001

exposure to allergens commonly associated with asthma, namely mite, cockroach, cat, and dog. The frequency of pet ownership was also very low. In this population, the risk of sensitization to cat increased among current cat owners, children who reported contact with cats during the first year of life, and those currently exposed to a high level of cat allergen. Current dog ownership and high exposure to dog allergen increased the risk of sensitization to dog. Sensitization to allergens, family history of asthma, history of whooping cough, and current cat ownership increased the risk for asthma, whereas breast-feeding was protective.

A high sensitization rate to cat in the current study is consistent with previous studies from Kuwait.^{21,22} The frequency of cat sensitization is similar to the data reported in some European^{23,24} and North American studies,^{25,26} but considerably higher compared with several other studies from Europe²⁷ and North and South America.^{28,29} In comparison with these communities, both the cat-keeping frequency and cat allergen levels in homes in Kuwait were markedly lower.^{23,25,27,30} Similarly, dog ownership was much less common, and dog allergen level in homes in Kuwait were considerably lower than in the United Kingdom and northern Sweden (eg, we estimate that Can f 1 in homes with dogs in Kuwait is ~30-fold lower compared with the homes of dog owners in the

United Kingdom and/or Sweden),^{23,30} and only marginally higher than the very low level found in Ghana.³⁰ Can f 1 concentration in the current study did not reach the level usually defined as the threshold for sensitization (10 µg/g) in any of the homes. Despite the fact very few families kept dogs at home and very low allergen levels, sensitization to dogs was common both in children with asthma (>30%) and in controls without asthma (~10%). Indeed, the dog sensitization rate in Kuwait is higher than that reported in most of the studies from Europe^{23,27} and the United States.^{26,28}

It was long assumed that pet ownership was a risk factor for sensitization. However, epidemiologic studies performed in areas with high prevalence of cat ownership failed to confirm this.^{9,11,31,32} There is now a body of evidence to suggest that in areas with a high proportion of cat ownership, the risk of sensitization to cats (and to other allergens) and of asthma decreases among cat owners.^{11,31,33} It has been hypothesized that high exposure to cat allergen may induce tolerance in some individuals.³⁴

All of the work suggesting a protective effect of pet ownership and pet allergen exposure comes from areas with a high proportion of pet ownership.^{9,11,31-34} Pet allergens are passively transferred from the homes of pet owners to homes without pets and to public places,²⁰ and

TABLE IV. Multivariate analysis of the risk factors for asthma*

	Adjusted OR (95% CI)	Significance
Asthma in other family member	3.03 (1.81-5.07)	<.001
History of whooping cough	5.96 (1.39-25.58)	.02
Current cat ownership	3.67 (1.00-3.74)	.05
Breast-feeding >2 mo	0.54 (0.30-0.96)	.04
Sensitization to		
<i>A alternata</i>	7.36 (2.50-21.65)	<.001
<i>Cladosporium</i>	4.70 (1.77-12.23)	.002
Trees mix	3.31 (1.38-7.95)	.007
Cat	3.11 (1.75-5.53)	<.001
House dust mite	3.20 (1.30-7.90)	.012

*Sensitization defined by skin prick testing (weal diameter 3 mm greater than negative control).

this passive exposure is likely to be higher in areas where pet ownership is more common. In such areas, it is likely that the passive exposure is sufficient for nonpet owners to become sensitized, and it is certainly true that sensitization cannot be prevented by banning pets from the home.³⁴ However, the results of studies conducted in areas with a high proportion of pet ownership may not apply to other areas with fewer cats and dogs. Indeed, we have previously demonstrated that the levels of pet allergens in Kuwait are very low in public places.³⁵ This, coupled with the findings of the current study of very low levels of pet allergens in homes of nonpet owners, suggests that individuals not owning a pet are probably not exposed to pet allergens, or that the level of exposure is very low. In an area like this, pet ownership markedly increases the risk of sensitization to pets. In addition, pet allergen levels in homes of pet owners in Kuwait appeared much lower in comparison with European and US studies, with levels arguably insufficiently high to induce tolerance. To a certain degree, this may be a consequence of lifestyle and housing (absence of carpets, frequent vacuum cleaning, air conditioning, and so forth).

Our data are consistent with the recent report from the European Community Respiratory Health Survey suggesting that cat ownership in childhood is associated with an increased risk in adult asthma among subjects who grew up in the area with relatively low public exposure to cats, but a cat at home was not associated with increased asthma risk in participants from areas with a high proportion of cat ownership.³⁶ Clearly, the effect of pet ownership may differ markedly between different areas and is related to the prevalence of pet ownership and the community exposure to pet allergens. This may at least in part explain the discrepancies between different studies. In areas with low pet ownership frequency, it is likely that pet ownership increases the risk of sensitization (and perhaps asthma).

However, it remains difficult to explain the high sensitization rate to pet allergens in the current study, in the area where allergen exposure is so low. In this study, we used measurement of current allergen exposure as a surrogate for the cumulative exposure, raising the

TABLE V. Multivariate analysis of the risk factors for asthma*

	Adjusted OR (95% CI)	Significance
Asthma in other family member	3.33 (1.98-5.60)	<.001
History of whooping cough	5.62 (1.35-23.33)	.018
Current cat ownership	5.29 (1.51-18.55)	.009
Breast-feeding >2 months	0.45 (0.26-0.80)	.006
Sensitization to		
<i>A alternata</i>	15.35 (7.18-32.83)	.001
<i>P juliflora</i>	2.39 (1.39-4.12)	.013

*Sensitization defined as a concentration of allergen-specific IgE >0.35 kU/L.

question whether the allergen level in a single dust sample can be considered an appropriate index of exposure. It has been argued that early-life allergen exposure is critical in the development of sensitization. However, because domestic allergen levels are very low, it is unlikely that the timing of dust collection has influenced the results.

Many Kuwaiti families spend their summer holidays in Europe and North America. Short exposure to pet allergens during the overseas visits may be one of the factors responsible for the high rates of sensitization to cats and dogs. This raises the real possibility that transient exposure can induce sensitization. It is also possible that factors other than allergen exposure are responsible for very high sensitization rates to cats and dogs in Kuwait.

Not surprisingly, we found that dust mite allergen levels in homes in Kuwait were very low. Der p 1 levels in all but 2 samples from homes were below the limit of detection. Der f 1 was detected at very low levels in only 2 samples from living rooms and 7 samples from bedding. Very low levels of Der p 1, below the limit of detection, were also observed in a neighboring desert country, Saudi Arabia.³⁷ Previous studies among children with asthma in Kuwait have also shown a broadly similar sensitization rate to dust mite compared with the current study.^{22,38} Interestingly, a study conducted in Kuwait 2 decades ago reported a much lower rate of sensitization to dust mite (1.5%).³⁹

Thus, comparing our data with those available from Kuwait 20 to 25 years ago, it would appear that the prevalence of both asthma and sensitization rates have increased dramatically. However, we must be cautious when comparing these data, because of the possibility that the differing methodology and extracts used to assess sensitization rates in these studies are responsible for at least a part of the observed differences cannot be discounted. Nevertheless, the data would suggest that there has been a real and substantial increase in the prevalence of sensitization in Kuwait over the period of the last 2 decades. Very low levels of indoor allergens found in dust in the presence of high rates of sensitization (80% among children with asthma) suggest that increase in indoor allergen exposure cannot be the major contributing factor to the apparent increase in sensitization, asthma prevalence, and asthma severity in Kuwait. Clearly, factors other than allergen exposure are responsible for the perceived dramatic increase in asthma and atopic sensitization in

this part of the world. This factor (or factors) could increase the susceptibility of the population to atopic sensitization and/or asthma, so that even very low levels of exposure could have induced sensitization.

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