

Prevalence of allergic sensitization to inhalant allergens among blood donors in Kuwait – a desert country

Ezeamuzie CI, Al-Mousawi M, Dashti H, Al-Bashir A, Al-Hage M, Al-Ali S. Prevalence of allergic sensitization to inhalant allergens among blood donors in Kuwait – a desert country.

Allergy 1997; 52: 1194–1200. © Munksgaard 1997.

Kuwait is a desert country where the prevailing high temperatures, low humidity, and scant vegetation suggest a low prevalence of allergy. We evaluated the prevalence of atopic sensitization (presence of allergen-specific IgE) among young adult blood donors by screening a total of 505 subjects (male : female ratio 1.6) with mean age of 28.4 years (range 18–50 years). The Pharmacia CAP-Phadiatop® test, which detects serum IgE specific to most common airborne allergens, was used. Some of the specific sensitizing allergens were also identified by the related CAP-RAST method. Sensitization was detected in 223 of the 505 subjects (44.2%) screened. Kuwaiti nationals had a significantly higher prevalence rate (50.2%) than non-Kuwaitis (34.2%) ($\chi^2=8.6$, $P<0.003$). The highest prevalence rate was found among male Kuwaitis (53.8%). The prevalence of current or previous allergic disease (subject-reported) was 20.6%. Bermuda grass, house-dust mite (*Dermatophagoides pteronyssinus*), and *Chenopodium album* were the most prevalent sensitizing allergens, with frequencies of 53.6%, 52.7%, and 50.9%, respectively, among the sensitized subjects (corresponding to 23.7%, 23.3%, and 22.5%, respectively) for the entire population. Sensitization increased with age, but only among the expatriates, younger Kuwaitis being as frequently sensitized as the older ones. Polysensitization was found to be common. Of the 109 CAP-RAST-positive subjects, 71 (65.1%) were sensitized to more than one allergen, and 30 of these (42.3%) were sensitized to four or more allergens. These results show that atopy is highly prevalent among young adults in Kuwait, and the higher prevalence rate among nationals than expatriates suggests the involvement of genetic or local environmental factors. The results also confirm that mite and plant pollens may be major sensitizing allergens even in a desert environment.

**C. I. Ezeamuzie¹, M. Al-Mousawi²,
H. Dashti¹, A. Al-Bashir³,
M. Al-Hage¹, S. Al-Ali⁴**

¹Department of Pharmacology and Toxicology, Faculty of Medicine, Kuwait University, Kuwait;

²General Family Medicine, Ministry of Public Health, Kuwait; ³Central Blood Bank, Jabriya, Ministry of Public Health, Kuwait; ⁴Allergy Centre, Ministry of Public Health, Kuwait

Key words: allergy; atopy; Kuwaiti; prevalence; Phadiatop; sensitization.

Dr Charles I. Ezeamuzie
Department of Pharmacology and Toxicology
Faculty of Medicine, Kuwait University
PO Box 24923, Safat, 13110
Kuwait

Accepted for publication 26 June 1997

Allergic diseases are among the most prevalent diseases in the world, and numerous epidemiologic studies have clearly demonstrated a significant and progressive increase in the prevalence during the last two decades (1–4). Current prevalence rates vary from 15% to 44% (1, 5) depending on the prevailing environmental factors, such as local aeroallergens and degree of exposure, air pollution, temperature, and humidity, as well as the age and the genetic disposition of the population.

Kuwait is a small desert country northeast of the Arabian Peninsula. The climate is dry and very hot in summer. The average day temperature is around

42°C, and the mean relative humidity ranges from 15% to 30%. The average annual rainfall is less than 15 cm, and there is little or no vegetation in most of the country. Such conditions are considered unfavorable to the availability of aeroallergens such as house-dust mite and pollens (6). Indeed, allergic diseases were extremely rare in Kuwait until the mid-1950s (7). Since then, however, the prevalence seems to have rapidly increased. Strannegard & Strannegard (8) found that within a period of 3 years, 1982–5, asthma admissions among Kuwaiti children had increased from 8.8% to 14.9% of all emergency admissions. Factors such

as oil pollution, temperature and humidity variations, increased use of air conditioners, frequent sandstorms, and pollen from the rapidly increasing local ornamental flora were believed to have contributed to the rapid increase (9–11). Nevertheless, no population prevalence study has been done, with the result that the prevalence of neither allergic diseases nor atopy is currently known.

There is also concern that the allergy situation may have further worsened since the Iraqi invasion of Kuwait when the population was exposed to unprecedented air pollution from over 600 burning oil wells. The association of air pollution with allergic diseases is well known (12–14). It has not been possible to assess adequately the impact of the air pollution on allergic sensitization or allergic diseases because of the lack of preinvasion baseline data. The identification of the local sensitizing allergens has received little attention. Allergens that are prevalent in the West are considered unlikely to be important here, and vice versa. For example, among asthmatics, it has been shown that positive skin reactions were by far more common to the pollens of the local plant *Prosopis juliflora* (mesquite) than to the house-dust mites *Dermatophagoides pteronyssinus* and *D. farinae*, which are among the most important allergens in the West (10).

Atopic sensitization is the basis of allergic diseases. Subjects with atopic allergy usually have some form of genetic disposition to produce IgE antibodies against harmless substances. Until recently, most epidemiologic surveys of atopy have usually employed the skin prick test (SPT) or the total IgE determination. The SPT has proved valuable because of its simplicity, low cost, and ability to detect the responsible allergen, but it is often imprecise, with considerable interstudy variability. Subject compliance may also be a problem in surveys of a healthy population. Total IgE determination, on the other hand, has rather serious specificity limitations. Although elevated total IgE levels are generally indicative of atopic allergy, many clinically proven allergic subjects may have normal total IgE levels (3), and patients may have increased IgE levels that result from parasitic infestation rather than allergy.

In recent years, the Pharmacia CAP-Phadiatop® test, which detects collectively the specific serum IgE antibodies to the most common aeroallergens, has become available for the *in vitro* screening of atopy. The value of this test in distinguishing atopic from nonatopic subjects in epidemiologic studies has been widely reported (15–18).

In the current study, we employed the Pharmacia CAP-Phadiatop method to determine the prevalence of allergic sensitization to airborne allergens

among the young adult segment of the Kuwaiti population and also to determine the common sensitizing allergens.

Material and methods

Subjects

The study involved a total of 505 young adults with a male to female ratio of 1.6 and mean age of 28.4 (range 18–50) years. They were recruited randomly (by random numbers) from among donors at the Central Blood Bank – a center for all blood donations in the country. Allergic diseases (unlike HIV, hepatitis, malaria, and other parasitic infections) are not exclusion criteria for blood donation, although prospective donors with overt allergic diseases, such as acute asthma, severe eczema, and atopic dermatitis, are often excluded.

All 505 subjects (84.3% of those initially requested to take part) gave informed consent before participating in the study and completed a simple questionnaire providing demographic data and history of allergy.

Kuwaiti nationals comprised 62.4% of the study population, the rest being mainly nationals of other Arab (Egyptians, Syrians, and Lebanese) and Asian countries (Indians, Iranians, Bangladeshis, and Filipinos). According to the questionnaire response, 121 out of a total of the 505 subjects studied (24.0%) had a family history of allergy, but only 104 (20.6%) had current or previous allergic disease. Clinical diagnosis was not carried out to confirm the questionnaire responses. The details of the characteristics of the sample population are given in Table 1.

Table 1. Characteristics of studied population sample

Characteristics	No. of subjects	%
All subjects	505	100
Sex		
M	314	62.2
F	191	37.8
Age (mean, range: 28.4;18–50 years)	–	–
Nationality		
Kuwaitis	315	62.4
Non-Kuwaitis	190	37.6
Family history of allergy		
Yes	121	24.0
None	284	56.2
Don't know	100	19.8
Current/previous allergic disease		
None	401	79.6
Asthma	24	4.7
Rhinitis	76	15.0
Eczema	17	3.4

Venous blood samples were taken from all the subjects between March and September, and the separated serum was stored at -43°C for less than 3 months before analysis.

IgE antibody measurement

The Pharmacia CAP-FEIA® test system (comprising the CAP-Phadiatop and the CAP-RAST tests) was employed throughout. The Phadiatop test, on which the prevalence analysis was entirely based, measures the specific IgE to a balanced mixture of common inhalant allergens. Results are expressed as either positive or negative by comparison to a reference serum, the value of which serves as the cutoff point for positivity. According to the manufacturer, about 95% of all truly atopic patients have values above this reference value. Sera from all the 505 subjects were subjected to this test.

Allergen-specific IgE determinations were made with the CAP-RAST test – a fluoroenzymatic modification of the conventional RAST. The assay was calibrated against the WHO IgE reference serum 75/502. The working range of the assay is 0.35–100 kIU/l. In both tests, serum samples and standards were incubated with allergen CAPs, and the bound antibody, after washing, was reacted with enzyme-labeled anti-IgE antibody. The release of the fluorescent product from the enzyme substrate was then measured by the fluorometer.

Some 112 samples selected according to random numbers from among the Phadiatop-positive samples were analyzed for the following six allergens: house-dust mite (*D. pteronyssinus*, d1); pollen of Bermuda grass (*Cynodon dactylon*, g₂), mesquite (*P. juliflora*, t20), the cajuput tree (*Melaleuca leucadendron*, t21), and goosefoot (*C. album*, w10); and mold mix (mx2) containing allergens from six different molds: *Penicillium notatum*, *Cladosporium herbarum*, *Aspergillus fumigatus*, *Candida albicans*, *Alternaria alternata*, and *Helminthosporium halodes*.

Analysis of data

All data were analyzed with the SPSS on a PC. The ratio of the Phadiatop fluorescence unit (FU) of the sample to that of the reference (cutoff) was used as an index of the degree of sensitization, and by relating this value to the total specific IgE content (by RAST in selected samples), the degree of sensitization was roughly classified into mild (FU ratio=1.0–3.9, moderate (FU ratio=4.0–9.9), or severe (FU ratio ≥10). Groups were compared by analysis of variance, and differences were tested either by the chi-square test or Fisher’s exact test. Significance was set at *P*<0.05. The severity of

sensitization of individual allergens was expressed in CAP-RAST classes of 0–6.

Results

Sensitization prevalence

Sensitization to airborne allergens (as Phadiatop-positive result) was detected in 223 out of the 505 subjects studied (44.2% overall prevalence rate) (Table 2). Among Kuwaiti nationals, 158 out of 315 (50.2%) were sensitized compared with 65 out of 190 (34.2%) expatriates, mainly nationals of other Arab and Asian countries. The difference in the prevalence of sensitization between Kuwaitis and non-Kuwaitis was highly significant ($\chi^2=8.6$, *P*<0.003). The highest prevalence rate was found among male Kuwaitis (53.8%), but this value did not differ significantly from that for female Kuwaitis (46.5%).

Fig. 1 shows the percent frequency of allergic disease as supplied in the questionnaire with respect to nationality. A total of 104 subjects (20.6%) claimed to have a current or previous allergic disease (asthma, rhinitis, and atopic skin disease either alone or in various combinations). However, only 84 subjects (16.6%) were found to be truly atopic (Phadiatop positive). Allergic diseases (truly atopic) tended to be more common among Kuwaitis (19.7%) than non-Kuwaitis (13.3%), but the difference was not statistically significant (*P*=0.1033).

The analysis of the degree of sensitization (estimated as the ratio of the Phadiatop fluorescence units of the sample to that of the reference sample) showed that 56.5% of the cases could be considered mild, 36.8% moderate, and 6.7% severe. When the rate of sensitization was analyzed according to two age groups, <25 years and ≥25 years, no significant

Table 2. Prevalence of allergic sensitization (positive Phadiatop)

Group	Phadiatop positive cases	% Phadiatop positive cases (% prevalence)
Kuwaitis		
Male (n=156)	84	53.8
Female (n=159)	74	46.5
Total (n=315)	158	50.2***
Non-Kuwaitis		
Male (n=158)	55	34.8
Female (n=32)	10	31.3
Total (n=190)	65	34.2
All subjects		
Male (n=314)	139	44.3
Female (n=191)	83	44.2
Grand total (n=505)	223	44.2

****P*<0.003 (chi-square) vs non-Kuwaitis.

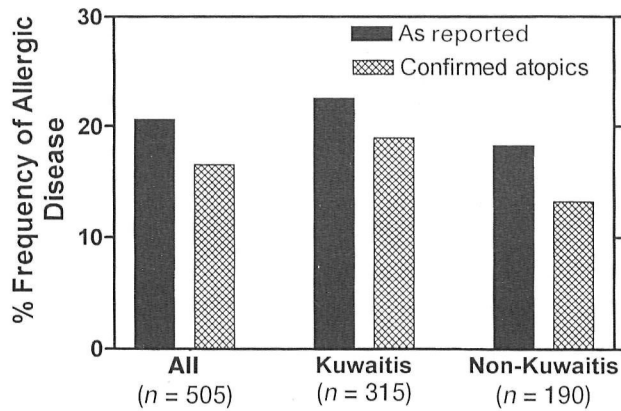


Fig. 1. Prevalence of allergic diseases (asthma, rhinitis, and atopic skin diseases) in studied population with respect to nationality. Values are given as percent frequency as obtained from questionnaire response (as reported) and as obtained when only truly atopic allergic patients (Phadiatop positive) were considered (confirmed atopics).

difference was seen for either the entire population or the Kuwaiti nationals (Fig. 2). However, for the expatriates, the younger age group had a significantly lower frequency of sensitization than the older ones (25.5% and 40.2%, respectively; $P < 0.05$). Within the younger age group, the frequency was much higher for Kuwaitis than for Non-Kuwaitis (49.7% and 25.5%, respectively; $P < 0.003$).

Sensitizing allergens

The analysis of the specific sensitizing allergens among the 112 atopic subjects tested is shown in Table 3. Bermuda grass, house-dust mite, and *C. album* had the highest frequency of positivity (53.6%, 52.7%, and 50.9%, respectively). Others were mesquite (39.3%), cajuput tree (25.0%), and

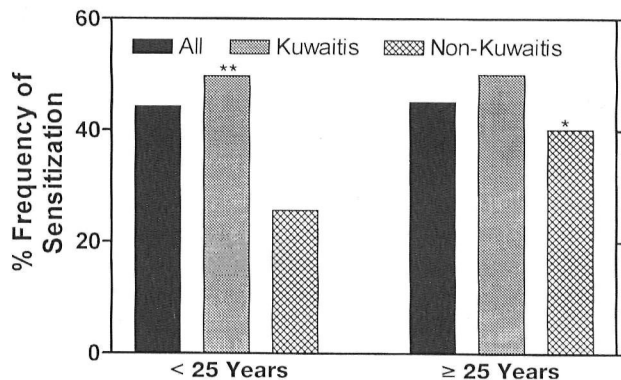


Fig. 2. Analysis of frequency of atopic sensitization with respect to age and nationality. * $P < 0.05$ (non-Kuwaitis over 25 years [$n = 132$] compared with non-Kuwaitis under 25 years of age [$n = 58$]). ** $P < 0.003$ (Kuwaitis under 25 years [$n = 163$] compared with non-Kuwaitis of same age group [$n = 58$]).

Table 3. Frequency of sensitization to individual allergens

Allergen	Frequency of sensitization (%)	
	Atopic group (Phadiatop positive)	Total studied population
Bermuda grass pollen (<i>Cynodon dactylon</i>)	53.6	23.7
House-dust mite (<i>Dermatophagoides pteronyssinus</i>)	52.7	23.3
<i>Chenopodium album</i> pollen	50.9	22.5
Mesquite pollen (<i>Prosopis juliflora</i>)	39.3	17.4
Cajuput tree pollen (<i>Melaleuca leucadendron</i>)	25.0	11.1
Mold (mix)	13.4	5.9

mold mix (13.4%). When extrapolated to the entire study population, the corresponding prevalences of sensitization for the six allergens were 23.7%, 23.3%, 22.5%, 17.4%, 11.1%, and 5.9%, respectively. Two subjects (1.8%) were negative for all the six allergens tested. The analysis of the severity of sensitization to the individual allergens, estimated as the percentage of subjects having CAP-RAST class 3 or over, showed that Bermuda grass, and, to a lesser extent, *C. album*, had a particular tendency to produce more severe sensitization than the others (data not shown).

The distribution of specific allergen sensitization among the two age groups (Table 4) showed no statistically significant differences. However, the older age group generally tended to have a higher sensitization rate to pollens (but not mite and molds) than the younger age group.

The analysis of the prevalence of polysensitization (Table 5) shows that 71 of the 109 subjects (65.1%) were sensitized to more than one allergen,

Table 4. Influence of age on sensitization to individual allergens among atopic subjects

Allergens	% Frequency of sensitization	
	< 25 years ($n = 52$)	≥ 25 years ($n = 58$)
House-dust mite (<i>Dermatophagoides pteronyssinus</i>)	55.8	50.0
Bermuda grass pollen (<i>Cynodon dactylon</i>)	50.0	58.6
Mesquite pollen (<i>Prosopis juliflora</i>)	36.5	43.1
Cajuput tree pollen (<i>Melaleuca leucadendron</i>)	23.1	27.6
<i>Chenopodium album</i> pollen	48.1	55.2
Mold mix (mx2)	13.5	13.8

Table 5. Frequency of polysensitization among atopic subjects

No. of allergens	No. of subjects sensitized	% Sensitized
1	38	34.9
2	25	22.9
3	16	14.7
4	22	20.2
5	7	6.4
6 (all)	1	0.9
Total monosensitized	38	34.9
Total polysensitized	71	65.1

30 of these (42.3%) being sensitized to four or more allergens.

Discussion

Kuwait is a desert country whose prevailing high temperatures, low humidity, and scant vegetation would suggest a low prevalence of allergy. This study reports a high prevalence rate (44.2%) of atopic sensitization to airborne allergens among adult blood donors. Interestingly, this figure was much higher for Kuwaiti nationals, of whom 50.2%, and as many as 53.8% of men, were sensitized. The prevalence rate among Kuwaitis is among the highest so far reported for this age group. For example, in a west London study, Sibbald et al. (3), using the SPT with a range of allergens, reported a prevalence of 44.0% for the 30–50-year age group, while Foucard (5), using the same method, reported a rate of 29% among Swedish medical students. In a more recent study which employed the same CAP-Phadiatop method as in ours, Matricardi et al. (17) found a sensitization prevalence of 34.3% in a population of Italian soldiers in the age range of 17–24 years. The value for a comparable age group (18–20 years) in the present study was 41.8% (50.0% among Kuwaitis).

To some extent, our study population may be considered representative of the general population of the same age and sex, in that allergic diseases are not among exclusion criteria for blood donation. However, blood-bank staff confirmed that prospective donors with obvious symptoms of asthma, severe rhinitis, or extensive atopic eczema were usually excluded. Furthermore, patients who have allergic diseases are unlikely to offer to donate blood. In this context, it is likely that our results represent an underestimation of the true population prevalence for this age group. This is perhaps part of the reason for the rather low prevalence of asthma (4.7%) and allergic rhinitis (15%) in the study population in a country where

allergic diseases are known to be very common (8, 11), the other reason being that clinical diagnosis of allergy was not specifically sought.

The reason for the high prevalence of atopic sensitization among Kuwaitis compared with their expatriate counterparts is uncertain. It is unlikely to relate to smoking habits since the prevalence of smoking (23–30%) was comparable in the two groups. A number of possible explanations may, however, be offered. Firstly, genetic predisposition to atopy may be more common among native Kuwaitis. Genes such as the HLA-DR2 and the T-cell receptor (particularly TcR α) are known to be associated with atopy (19, 20), but no linkage studies of these or other genes in relation to atopy have been done for the local population. Secondly, it could be the result of a longer exposure to local allergens or pollutants for the natives than the expatriates, who are largely migrant workers in constant movement. It is also possible that the massive air pollution that occurred in 1991 when the invading Iraqi forces ignited over 600 oil wells contributed to the high sensitization rate, given the well-known relationship between air pollution and allergic sensitization (12–14). This, however, is difficult to assess, since, unfortunately, no preinvasion prevalence data are available for comparison. The mere fact that the prevalence was much higher among Kuwaitis, most of whom were exposed to the oil fire smoke for many months, than among the expatriates, most of whom left the country at the time, is consistent with such a possibility. With such a markedly higher frequency of allergic sensitization among Kuwaitis than expatriates, one would expect a higher prevalence of allergic diseases in the former. Although such a trend was seen (Fig. 1), the difference did not reach statistical significance. This could be due to the fact that in this population sample the degree of sensitization was mild to moderate in most (90%) cases. It must also be realized that patients with active or severe allergic disease are unlikely to offer to donate blood – a fact that must have contributed to the possible underrepresentation of allergic patients in the studied population.

Another important observation is that 38.9% of all subjects who claimed never to have had allergic diseases were found to be sensitized. This suggests that a large pool of sensitized, but asymptomatic individuals exists in this population. Although not all atopic individuals eventually develop allergic diseases, they represent a particularly high risk group, given the close association between the prevalence of allergic diseases such as asthma and rhinitis and that of atopy (21, 22).

All but two of the 112 Phadiatop-positive subjects screened for the specific IgE were positive to

at least one of the six allergens tested, a fact which suggests that these allergens are largely responsible for the sensitization of the population. Bermuda grass, house-dust mite, and *C. album* were the most frequent sensitizing allergens (around 50% frequency for each) among atopic subjects. This corresponds to a prevalence rate of about 22% for each of the allergens in the entire population, which may be considered high in comparison with other values for a normal population (15). These results agree broadly with the SPT positivity among asthmatics in Kuwait, except for house-dust mite, whose frequency has been reported to be very low (8, 10). The authors attributed this low prevalence of mite sensitization to the high temperatures and low mean relative humidity, which are thought to be unsuitable for the growth of mites (6). The relatively lower frequency of sensitization to mite in that study, in spite of the comparable values for Bermuda grass and *C. album* seen in the present study, may reflect a lower capacity of mite sensitization to develop into asthma, since that study, unlike the present one, was done only on asthmatics. This point is currently being assessed in asthmatics. It is, however, important to point out that the extensive use of air conditioners in Kuwait may well have created the indoor climatic condition conducive to mite growth.

Bermuda grass pollens and, to a lesser extent, those of *C. album* tended to cause more severe sensitization than the other allergens. Whether this relates to a higher allergenic potency of these pollens or higher abundance in the environment is not yet known. These plants, together with *P. juliflora* (mesquite), occur abundantly in Kuwait, where they are planted as shade or ornamental trees or for binding sand. The analysis of the influence of age on the frequency of sensitization revealed an interesting observation. Sensitization frequency appeared to increase with age, but only among expatriates. This suggests that younger Kuwaitis tend to become sensitized much earlier than their expatriate counterparts, obviously accounting for the observed overall higher prevalence of sensitization among Kuwaitis. These observations are consistent with the possible involvement of environmental and/or genetic factors in these differences, as discussed above.

Our results also showed a high prevalence of polysensitization, as up to 65% of all sensitized subjects were positive for more than one allergen. In fact, as many as 42.2% of such subjects were sensitized to four or more allergens. Polysensitization has been associated with a heightened tendency to evoke an IgE response, even to allergens in very low concentrations, and that may, in turn, arise from both genetic disposition and the duration of exposure (5, 23).

Taken together, our results show that the prevalence of allergic sensitization among young adult Kuwaitis is high and that, contrary to popular belief, sensitization to house-dust mite and plant pollens can be highly prevalent in a desert environment where the prevailing climatic conditions and scanty vegetation would predict otherwise. The results have serious social and public health implications since the practices that make the desert habitable (air conditioning and horticultural practices) may also encourage the generation of potent airborne allergens.

The high sensitization rate found in this study is consistent with the high prevalence of allergic diseases, especially asthma and rhinitis, in the wider population and supports the notion that increased allergic sensitization invariably leads to increased allergic diseases. It remains to be determined to what respective extents the genetic and the environmental factors contribute to the high prevalence of allergic sensitization and disease in this community.

Acknowledgments

We thank the director and staff of the Kuwait Central Blood Bank, Jabriya, for their cooperation in subject recruitment and blood sampling. This work was supported by Kuwait University Research Grant no. MR 036

References

1. Åberg N, Hesselmar B, Åberg B, Eriksson B. Increase of asthma, allergic rhinitis and eczema in Swedish school-children between 1979 and 1991. *Clin Exp Allergy* 1995;25: 815-19.
2. Burr M, Butland B, King S, Vaughan-Williams E. Changes in asthma prevalence: two studies 15 years apart. *Arch Dis Child* 1989;64:1118-25.
3. Sibbald B, Rink E, D'Souza M. Is the prevalence of atopy increasing? *Br J Gen Pract* 1990;40:338-40.
4. Wüthrich B. Epidemiology of allergic diseases: are they really on the increase? *Int Arch Allergy Appl Immunol* 1989;90:3-10.
5. Foucard T. Allergy and allergy-like symptoms in 1,050 medical students. *Allergy* 1991;46:20-6.
6. Spijksma FTM, Zuidema P, Leupen MJ. High altitude and house dust mite. *BMJ* 1971;1:82-4.
7. Wilkinson WM. Development of allergy in the desert. *J Trop Med Hyg* 1964;67:16-18.
8. Strannegard IL, Strannegard O. Childhood bronchial asthma in a desert country. *Allergy* 1990;45:327-33.
9. Al-Awadi AA. Study of allergy in Kuwait. I. Prevalence and role of environmental factors. Monograph, Ministry of Public Health, Kuwait, 1973.
10. Ellul-Micallef R, Al-Ali S. The spectrum of bronchial asthma in Kuwait. *Clin Allergy* 1984;14:509-17.
11. Mohamed DE, Hail MA, Al-Kazmy K. Environmental factors in relation to allergic complaints. Monograph, Ministry of Public Health, Kuwait, 1983.
12. Ishizaki T, Koizumi K, Ikeromi R, Ishiyama Y, Kushibiki E. Studies of the prevalence of Japanese cedar pollinosis among the residents of a densely cultivated area. *Ann Allergy* 1987;58:265-70.

13. Omran M, Russel G. Continuing rise in the prevalence of asthma-like symptoms and diagnosed atopic disease in Aberdeen schoolchildren. *Eur Respir J* 1995;8:495s.
14. Pécoud A. Pollution atmosphérique et allergies. *Schweiz Rundsch Med Prax* 1988;77:1261-3.
15. Eriksson NE. Allergy screening with Phadiatop and CAP Phadiatop in combination with a questionnaire in adults with asthma and rhinitis. *Allergy* 1990;45:285-92.
16. Kohl C, Debelic M. *In vitro* screening for inhalant allergy with multi-SX1 RAST (Phadiatop). *Allergy* 1991;46:245-50.
17. Matricardi PM, Nisini R, Biselli R, D'Amelio R. Evaluation of the overall degree of sensitization to airborne allergens by a single serologic test: implications for epidemiologic studies of allergy. *J Allergy Clin Immunol* 1994;93:68-79.
18. Merrett J, Merrett TG. Phadiatop: a novel IgE antibody screening test. *Clin Allergy* 1987;17:409-16.
19. Cookson W. Polygenes, asthma and atopy. In: Chanaz P, Bousquet J, Michel FB, Godard P, editors. *From genetics to quality of life: the optimal management and treatment of asthma*. Seattle, WA: Hogrefe and Huber, 1996:15-19.
20. Marsh DG, Meyers DA, Bias WB. The epidemiology and genetics of atopic allergy. *N Engl J Med* 1981;305:1551-9.
21. Burrows B, Martinez ED, Halonen M, Berbee RA, Cline MG. Association of asthma with serum IgE levels and skin-test reactivity to allergens. *N Engl J Med* 1989;320:271-7.
22. Freidhoff LR, Marsh DG. The relationship among asthma, serum IgE and skin-test sensitivity to inhaled allergens. *Int Arch Allergy Appl Immunol* 1993;100:355-61.
23. Niemeijer NR, de Monchy JGR. Age dependency of sensitization to aeroallergens in asthmatics. *Allergy* 1992;47:431-5.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.