doi: 10.1111/j.1365-2222.2011.03891.x
Clinical & Experimental Allergy, 1–22
REVIEW

Prevalence and diversity of allergic rhinitis in regions of the world beyond Europe and North America

C. H. Katelaris[1], B. W. Lee[2], P. C. Potter[3], J. F. Maspero[4], C. Cingi[5], A. Lopatin[6], M. Saffer[7], G. Xu[8] and R. D. Walters[9,*]

[1]Immunology & Allergy, Campbelltown Hospital, University of Western Sydney, New South Wales, Australia, [2]Department of Paediatrics, National University Hospital, Singapore, [3]Allergy Diagnostic and Clinical Research Unit, University of Cape Town Lung Institute, Cape Town, South Africa, [4]Fundación Cidea, Buenos Aires, Argentina, [5]Department of Otorhinolaryngology, Medical Faculty, Osmangazi University, Eskisehir, Turkey, [6]Clinic of Ear, Nose and Throat Diseases, First State Medical University, Moscow, Russia, [7]Complexo Hospitalar Santa Casa de Porto Alegre, Ambulatório de Otorrino, Porto Alegre, Brazil, [8]Allergy and Cancer Center, Otorhinolarygology Hospital of the First Affiliated Hospital of Sun Yat-sen University, and Otorhinolaryngology Institute of Sun Yat-sen University, Guangzhou, China and [9]GlaxoSmithKline, Asia Pacific Japan & Emerging Markets (APJEM) Medical Affairs, Brentford, London, UK

Clinical & Experimental Allergy

Background There is comparatively little information in the public domain on the diversity in prevalence and triggers/factors associated with allergic rhinitis (AR) or allergic rhinoconjunctivitis (AR/C) in countries beyond western-Europe and North America.
Objective To review the prevalence and the sensitizing agents/triggers and factors associated with AR/C in several countries in Africa, the Asia-Pacific region, Australia, Eastern Europe, Latin America, Middle East and Turkey.
Methods Articles published in English in peer-reviewed journals were assessed and selected for further review, following an extensive literature search using the Medline database.
Results This review demonstrated that prevalence of AR and AR/C in these regions has predominantly been investigated in children; with studies indicating wide inter- and intra-regional variations ranging from 2.9% AR and 3.8% AR/C in 10–18-years-old children from one region in Turkey to 54.1% AR and 39.2% AR/C in 13–14-years-old children in one region in Nigeria. Moreover, the prevalence of AR and AR/C has increased markedly over the last decade particularly in some of the more affluent African countries, China-Taiwan and several Middle East countries, likely as a consequence of improved living standards leading to increased exposure to multiple traditional and non-traditional sensitizing agents and risk factors similar to those noted in western-Europe and North America.
Conclusions and Clinical Relevance Our findings suggest that the greater diversity in prevalence of AR or AR/C in populations in these regions is in contrast to the lower diversity of AR or AR/C in the ‘western populations (USA and Europe), which tend to be more uniform. This review provides a comprehensive database of the important allergens and triggers which are likely to influence the prevalence of allergic rhinitis in these diverse regions, where the prevalence of allergic rhinitis is increasing and its adverse impact on the quality of life of affected individuals is increasingly recognised.

Keywords allergen diversity, allergic rhinitis, allergic rhinoconjunctivitis, low-to-middle income countries, prevalence
Submitted 14 April 2011; revised 01 September 2011; accepted 02 September 2011

Correspondence:
Richard Walters, GlaxoSmithKline Asia Pacific, Japan & Emerging Markets, Medical Affairs, GSK House, 980 Great West Road, Brentford, TW8 9GS, UK.
E-mail: richard.d.walters@gsk.com

Introduction

Although allergic rhinitis (AR)/allergic rhinoconjunctivitis (AR/C) is a common chronic respiratory disorder world-wide, its manifestations differ in different parts of the world. Unlike in the northern hemisphere regions such as Europe and the United States, with well-defined seasons, the presentation of rhinitis is likely to be different in other parts of the world where there are no seasonal variations or very long dry seasons or very long summers.

Allergic rhinoconjunctivitis is characterized by sneezing, rhinorrhoea, nasal congestion and nasal pruritus, which are often accompanied in 60–70% of patients by ocular pruritus/redness and or lacrimation [1, 2]. Although not life threatening, AR/C symptoms are frequently bothersome, adversely affect work and quality of life of the affected individual and impose a significant burden on both the individual and society [1–4]. The symptoms additionally have the potential to lead to both physical and mental complications, with sleep-disordered breathing in childhood and adolescence being associated with increased learning performance, behaviour and attention disorders [5, 6]. Indeed, the Paediatric Allergies in America survey [7] has recently provided compelling evidence that children with nasal allergies experienced substantially more physical, mental, emotional and social problems than children without allergies. Furthermore, the burden of AR/C on children was likely to be significantly underestimated, particularly as healthcare providers overestimated the patients' and parents' satisfaction with disease management and the benefit of medications used for the treatment of nasal allergies in children [7]. Similarly, the Burden of rhinitis in America survey [8] has demonstrated that adults with AR/C also experience a substantial burden on their ability to sleep, quality of life and workplace productivity, compared with subjects with no AR symptoms.

Despite the availability of evidence-based treatment guidelines, such as the World Health Organisation (WHO)-sponsored Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines [9], evidence suggests that general practitioners who do not use the guided treatment strategy often misdiagnose the severity of the disease and therefore treat their patients inappropriately, in turn leading to low patient satisfaction and compliance [10, 11]. Furthermore, anecdotal evidence indicates that this situation may be more prominent in the developing countries, where, unlike asthma, AR or AR/C is often trivialized and socio-demographic and cultural differences are likely to play a vital role in the diagnosis and management of AR or AR/C. This situation is further compounded by the fact that presently there is no clear definition of what constitutes total AR or AR/C 'control', as not all patients with moderate/severe AR or AR/C are controlled even on optimal pharmacotherapy [9].

Epidemiological studies have indicated that the prevalence of AR has increased progressively over the last three decades in the more developed 'westernized' societies and presently affects up to 40% of the population worldwide [9, 12], with 23–30% of the population affected in Europe [13, 14] and 12–30% of individuals affected in the United States [15]. Studies in 6–14-year-old children from around the globe have indicated that the prevalence of AR has doubled in many countries over the last two decades [16–20]. Although the diversity and the prevalence and the triggers/factors responsible for development of AR is well documented for the developed 'westernized' countries, there is comparatively little similar information in the public domain for countries beyond western-Europe and North America, particularly the developing and low-to-middle income countries [21]. The present article thus reviews the diversity of prevalence of AR or AR/C and the sensitizing agents/triggers and other factors associated with these conditions in several countries in Africa, the Asia-Pacific region, Australia, Eastern Europe, Latin America, Middle East and Turkey.

Search strategy

The process for selection of articles for inclusion in the review is shown in Fig. 1. A literature search was conducted in August 2010 for all relevant articles using PubMed, a comprehensive biomedical literature database providing access to MEDLINE, life science journals and online books. Citations for articles documenting the prevalence of AR and factors associated with the development of symptoms of disease were identified using *AR, seasonal allergic rhinitis* (SAR) *and perennial allergic rhinitis* (PAR) as the primary search terms in association with '*prevalence incidence*' *and specific countries/regions of interest, including* Africa (*Egypt, Ethiopia, Kenya, Morocco, Mozambique, Nigeria, South Africa, Tunis, Zimbabwe*), Asia-Pacific (*China, Hong Kong, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand*), Australia, Eastern Europe (*Russia*), Latin America (*Argentina, Brazil, Chile, Columbia, Costa Rica, Mexico, Peru, Venezuela*), Middle East (*Iran, Israel, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, United Arab Emirates*) and Turkey. A total of 3675 citations were highlighted using these search terms, and thus the results of the search were limited to articles published during the period January 1980 to August 2010. Potential articles for inclusion were initially identified by the title and the specific study details in the abstracts. Because of the wide diversity in methods, instruments and descriptions used for determining and documenting the prevalence of AR/ARC in the regions of interest, it was not possible to assess the quality of the articles according to any pre-determined criteria for inclusion in the review. Thus, only full articles published in English and in peer-reviewed journals were selected based on the relevance of their abstracts and reviewed further for more detailed information.

Prevalence of AR or AR/C

The studies reporting prevalence of AR or AR/C in the regions of interest have predominantly investigated the prevalence of disease in children, with the majority of these employing the standardized and appropriately translated versions of the International Study of

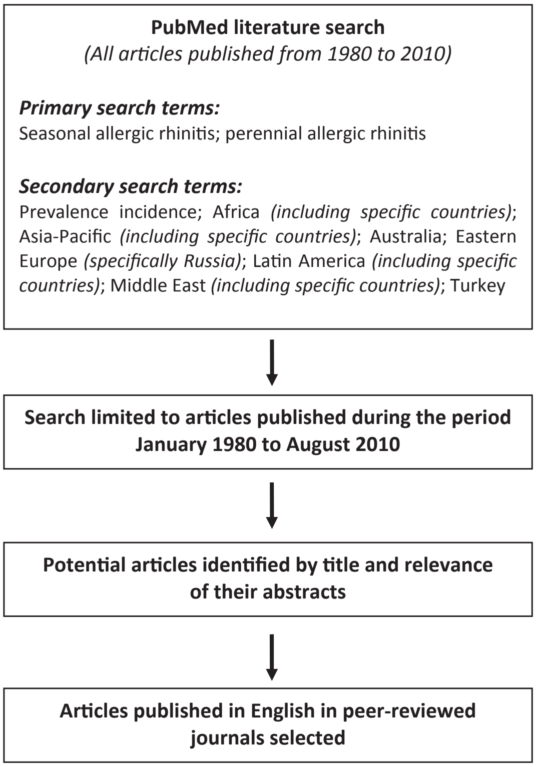

Fig. 1. Flow diagram showing selection of articles reviewed.

Asthma and Allergies in Childhood (ISAAC) written and/or video questionnaires [22–24]. In comparison, there are relatively few studies in adults. Overall, studies have indicated wide variations in prevalence of AR or AR/C between the countries, as well as within different regions of individual countries (Fig. 2 and Table 1) [25–109]. These range from 2.9% AR and 3.8% AR/C in children from one region in Turkey [97] to 54.1% AR and 39.2% AR/C in 13–14-year-old children in one region in Nigeria [32]. The more recent studies have further indicated that the prevalence of AR and or AR/C has increased markedly, particularly in some of the more affluent African countries, 'China-Hong Kong-Taiwan' and several Middle East countries.

Prevalence in children

Africa. The vast majority of studies reporting the prevalence of AR or AR/C in Africa to date have investigated the prevalence of disease in children aged 6–15 years, using the ISAAC study questionnaires either alone or in conjunction with another locally modified questionnaire aimed at answering specific questions regarding the potential risk factors of allergic disease [25–35]. Prevalence of AR/C was found to be lowest in Morocco [29] and Mozambique [30], ranging in different centres from 8.8% to 28% in 13–14-year-old children and from 8.5% to 23% in 6–7-year-old children, respectively. In contrast, highest prevalence of 54.1% AR and 39.2% AR/C was reported in ISAAC Phase I studies in 13–14-year-old children in a region in Nigeria [32]. However, a more recent ISAAC Phase III study involving over a million children aged 6–14 years from all the major regions of the world has demonstrated that currently the regional average prevalence of AR/C is highest for Africa (18.0%) and ranges from 20.7% in Wilaya of Algiers, Algeria to 33.3% in Brazzaville, Congo [36].

Asia-Pacific. Although several studies have investigated the prevalence of AR or AR/C in children/adolescents and adults in the Asia-Pacific region [37–59], the

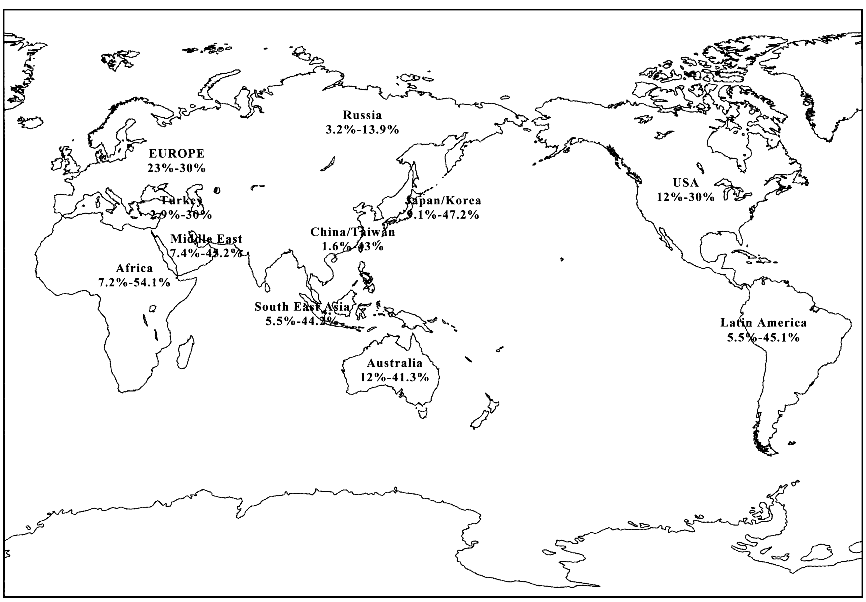

Fig. 2. Prevalence of AR or AR/C in different regions of the world.

Table 1. Studies documenting variation in prevalence of allergic rhinitis (AR) and allergic rhinoconjunctivitis (AR/C) in diverse and developing regions around the world

Region/ Country	Population characteristics	Study location type	Study design/ method for assessing prevalence	% Prevalence of AR and/or AR/C (lifetime, unless stated otherwise)	Reference
Africa	60 350 children aged 13–14 years	Rural and urban centres	ISAAC study questionnaires	7.2–27.3% AR/C	[25]
Egypt	2645 children aged 11–15 years	Cairo (urban)	ISAAC study questionnaires	15.3% AR/C (physician diagnosed)	[26]
Ethiopia	3365 children aged 13–14 years	Gondar (suburban)	ISAAC study questionnaires	14.5% AR within past 12 months	[27]
Kenya	3018 children aged 13–14 years	Uasin Gishu district (rural)	ISAAC study questionnaires	32.4–43% AR; 11.8–24.1% itchy eyes	[28]
Morocco	5728 children aged 13–14 years	Casablanca, Marrakech, Ben Slimane, Boulmane	ISAAC study questionnaires	8.8–28% AR/C	[29]
Mozambique	2283 children aged 6–7 years 2630 children aged 13–14 years	Maputo (urban, suburban and semi-rural)	ISAAC study questionnaires	8.5% AR/C in 6–7 years old; 23.0% AR/C in 13–14 years old	[30]
Nigeria	2325 children aged 6–7 years 2383 children aged 13–14 years	Ibadan (urban)	ISAAC study questionnaires	11.3% AR in 6–7 years old; 54.1% AR/39.2% AR/C in 13–14 years old	[31, 32]
South Africa	5037 children aged 13–14 years	Cape Town (urban)	ISAAC study questionnaires	38.5% AR and 24.3% AR/C within past 12 months	[33]
Tunis	3350 children aged 13–14 years	Grand Tunis (Ariana, Ben Arous, Manouba, Tunis)	ISAAC study questionnaires	29.7% AR/C within past 12 months	[34]
Zimbabwe	84 children aged ≤12 years	Harare (private paediatric clinic; urban)	Retrospective descriptive study using RAST testing	15.6% AR; 24.0% AR/C (RAST+ve)	[35]
Asia-Pacific					
China	1211 children aged 3–6 years	Wuhan (urban)	Questionnaire and skin-prick tests	10.8% AR in Wuhan	[37]
	737 children aged 12–20 years	San Bu (urban)		1.6% AR within past 12 months and 2.1% AR and in children living in San Bu	[38, 39]
	7754 children aged 6–7 years	Urumqi & Beijing (urban)	ISAAC study questionnaires	30–31.1% AR within past 12 months	[40]
	General population	11 major cities across China	Telephone interview – self-reported symptoms	8.7–24.1% AR	[41]
Hong Kong	1062 children aged 12–20 years	Hong Kong	Questionnaire and skin-prick tests	15.7% AR	[39]
	Two cohorts of 3618 and 4448 children aged 6–7 years	Hong Kong (urban)	ISAAC study questionnaires	35.1% AR within past 12 months; 42.4% cumulative physician-diagnosed AR; and 37.4% current AR and 17.2% current AR/C	[42, 43]
Japan	468 children aged 13–14 years	Vientiane city (urban)	ISAAC study questionnaires	24.4% AR/C	[44]
	755 children aged 12–13 years	Hidaka Province (mountainous area)	Questionnaire and skin-prick tests	9.1–15.8% AR/C	[45]
	2307 adult males	Tokyo (urban)	Self-reported symptoms study	35.5% AR, 28.8% SAR and 11.0% cedar pollinosis	[46]

(continued)

Table 1 (continued)

Region/ Country	Population characteristics	Study location type	Study design/ method for assessing prevalence	% Prevalence of AR and/or AR/C (lifetime, unless stated otherwise)	Reference
Korea	Two cohorts of 2005 and 2055 children aged 7–18 years living near orchards and 1000 children aged 7–16 years living in urban areas	Cheju island (rural) and Seoul (urban)	ISAAC study questionnaires	13.6% AR/C 35.7% AR within past 12 months in rural areas with citrus farms and 22.4% in children living in urban areas without citrus farms	[47, 48]
	2467 adults aged 20–50 years	Seoul (metropolitan urban), Cheonan and Icheon (non-metropolitan urban), & Khoisan (rural)	Standardized questionnaire	16.4–24.7% AR	[49]
	181 subjects aged 18–87 years	Cheju island (rural)	Questionnaire and skin-prick tests	12.1% by questionnaire; 19.3% by positive skin-prick test	[50]
Malaysia	409 children aged 12–20 years (ethnic Chinese only)	Kota Kinabalu (urban)	Questionnaire and skin-prick tests	11.2% AR	[39]
Singapore	9636 children aged 6–15 years	Singapore (urban)	ISAAC study questionnaires	25.5–42.1% AR within past 12 months	[51]
	2868 adults aged 20–74 years	Singapore (urban)	Standardized questionnaire	5.5% AR	[52]
Taiwan	Four cohorts of between 11 580 and 75 960 children aged 7–15 years	Central Taiwan (urban)	ISAAC study questionnaires	12.5–27.6% AR; 43.0% overall 12 month AR prevalence	[53, 54]
	6190 children aged 6–15 years	Taoyuan (urban)	ISAAC study questionnaires	18.3–29.8% AR	[55]
	8723 children aged 1–8 years	Tou-Cheng,Taipei (urban)		39.6% AR 12 month prevalence and 24.1% physician-diagnosed AR	[56]
	14 201 children aged 7–15 years	Taichung (urban) and Chu-Shan (rural)	Questionnaire based	27.6% AR in Taichung and 21.8% AR in Chu-Shan	[57]
	33 1686 non-smoking schoolchildren aged <6 to ≥15 years	Nationwide (24 counties and cities in Taiwan)		34–42.4% questionnaire-based AR; 19.5–28.6% physician-diagnosed AR	[58]
Thailand	7341 children aged 6–14 years	Bangkok and its vicinity	ISAAC study questionnaires	17.9–44.2% AR	[59]
Australia	1509 preschoolchildren aged 4–5 years	South Australia (urban/rural)	ISAAC study questionnaires	20.8% AR within past 12 months	[60]

(continued)

Table 1 (continued)

Region/ Country	Population characteristics	Study location type	Study design/ method for assessing prevalence	% Prevalence of AR and/or AR/C (lifetime, unless stated otherwise)	Reference
	Two cohorts of 2968 and 2686 children aged 6–7 years; 3607 children aged 13–14 years	Adelaide, Melbourne, Sydney, Perth (metropolitan)	ISAAC study questionnaires	12.7% overall 12 months AR prevalence and 12.0% current AR in 6–7 years old; 19.6% current AR in 13–14 years old	[61, 62]
	1499 children aged 7–12 years old (158 were Aboriginal)	Moree, Wagga Wagga (rural NSW)	Questionnaire and skin-prick test study	23.3% AR in Aboriginal children and 35.4% AR in non-Aboriginal children	[63]
	1494 stratified adult cohort aged 29–32 years	Tasmania (urban/rural)	Self-reported symptoms population-based study	41.3% AR	[64]
	3411 children aged 13–14 years	Moscow (metropolitan)	ISAAC study questionnaires	12.8% AR ever and 6.4% AR/C	[65]
	1106 children aged 17–16 years (587 Russian; 519 Finn)	Svetogorsk (Russia; urban); Imatra (Finland	ISAAC study questionnaires	15.2% vs. 8.8% AR and 4.7% vs. 3.2% AR/C in Imatra and Svetogorsk	[66]
	4470 adults (3368 Russian; 1102 Norwegian)	Nikel (Russia; polluted urban); Sør-Varanger (Norway; urban)	Self-administered questionnaire	13.9% AR/C 5.6% vs. 10.3% lifetime AR prevalence in Nikel and Sør-Varanger	[67, 69]
Latin America	93 851 children aged 6–7 years and 165 917 aged 13–14 years	14–17 Latin American countries	ISAAC study questionnaires	12.7% (range 5.5–21.2%) AR/C in 6–7 years old and 18.5% (range 7.1–45.1%) AR/C in 13–14 years old	[69]
Brazil	23 422 children aged 6–7 years and 58 144 aged 13–14 years	20 cities across Brazil (urban and rural)	ISAAC study questionnaires	10.3–17.4% AR/C in 6–7 years old and 8.9–28.5% AR/C in 13–14 years old	[70]
	3312 children aged 6–7 years	Western districts of São Paulo (polluted urban)	ISAAC study questionnaires	25.7% AR/C and 11.3% doctor-diagnosed AR	[71]
	3009 children aged 13–14 years	Brasilia (urban)	ISAAC study questionnaires	20.0% diagnosed rhinitis, 29.3% recent rhinitis and 12.2% AR	[72]
	3628 children aged 13–14 years	Curitiba (metropolitan)	ISAAC study questionnaires	17.2% current AR/C	[73]
	11 403 children aged 6–7 years and 20 587 aged 13–14 years	7 cities across North and South of Brazil (urban)	ISAAC study questionnaires	26.6% AR in 6–7-year-old children and 34.2% AR in 13–14-year-old children	[74]
Mexico	5238 children aged 6–14 years	Cuernavaca city (urban)	ISAAC study questionnaires	8.2% AR/C	[75]
	6174 children aged 6–14 years	Juarez (metropolitan)	ISAAC study questionnaires	4.7–5.4% physician-diagnosed AR in 6–8 and 11–14 years old, respectively	[76]
Middle East					
Iran	2999 children aged 6–7 years	Urmia city (urban)	ISAAC study questionnaires	9.8% AR within past 12 months	[77]
	4584 children aged 11–15 years	Shiraz City (urban)	Questionnaire and ENT examination-based study	22% AR (questionnaire) and 9.7% (ENT physician/questionnaire)	[78]

(continued)

Table 1 (continued)

Region/ Country	Population characteristics	Study location type	Study design/ method for assessing prevalence	% Prevalence of AR and/or AR/C (lifetime, unless stated otherwise)	Reference
Israel	1243 children aged 8–17 years (585 Jewish; 658 Arab)	Zichron Yaakov and Paradis (seashore towns)	ATS-NHLI Health questionnaire	19.7% AR in Jewish children and 9.7% AR in Arab children	[79]
Kuwait	Two cohorts of 2882 and 3110 children aged 13–14 years	Kuwait (urban)	ISAAC study questionnaires	41.4–43.9% AR; 27.6–30.7% 12-month AR prevalence; 17.1–22.2% physician-diagnosed AR	[80, 81]
Lebanon	Two cohorts of 3115 and 3909 children aged 5–14 years	5 provinces across Lebanon	ISAAC study questionnaires	21.2–45.2% AR; 38.6% AR within past 12 months	[82, 83]
	Children aged 13–14 years	Beirut (metropolitan city)	ISAAC study questionnaires	25.5% AR and 15.9% AR/C	[84]
Oman	3893 children aged 6–7 years and 3174 aged 13–14 years	Nationwide (urban and rural areas)	ISAAC study questionnaires	7.4% AR in 6–7-year-old children and 10.5% AR in 13–14 years old	[85]
Qatar	3283 children aged 6–14 years	Nationwide (both urban and rural areas)	ISAAC study questionnaires	30.5% physician-diagnosed AR	[86]
Saudi Arabia	9540 children aged 6–15 years	Nationwide (both urban and rural areas)	ISAAC study questionnaires and skin-prick test	26.5% AR and 25.7% physician-diagnosed AR	[87]
	3131 children aged 8–16 years	Jeddah, Riyadh, Hail and Gizan (inland dry desert or coastal humid cities)	ISAAC study questionnaires	Mean 25% AR	[88]
United Arab Emirates	6543 children aged >13 years	Al-Ain City (urban)	ISAAC study questionnaires	36.0% AR within past 12 months	[89]
	3200 children aged 6–13 years	7 Emirates (urban/ rural)	ISAAC study questionnaires	14.9% physician-diagnosed AR	[90]
	850 children aged 6–14 years	Urban and rural areas	Self-administered questionnaires	22.9% AR	[91]
Turkey	931 children aged 7–14 years	Bolu (rural/urban areas)	ISAAC study questionnaires	23.2% AR	[92]
	7245 children aged 13–14 years	Manisa (mountainous)	ISAAC study questionnaires	14.5% AR and 13.0% AR/C	[93]
	1018 children aged 4–12 years	Istanbul (shanty town area with poor hygiene)	ISAAC study questionnaires and skin-prick tests	26.2% current AR	[94]
	Two cohorts of 2500 and 2276 children aged 6–15 years	Istanbul (several urban areas)	ISAAC study questionnaires	7.9% physician-diagnosed AR; 17.6% AR	[95, 96]
	1217 children aged 9–11 years	Izmir (urban/rural areas)	ISAAC study questionnaires	30% AR within past 12 months and 17% physician-diagnosed AR	[97]
	1108 children aged 10–18 years	Sanliurfa (metropolitan)	ISAAC study questionnaires	2.9% AR and 3.8% AR/C	[98]
	1349 children aged 6–16 years	Zonguldak (urban)	ISAAC study questionnaires	37.7% physician-diagnosed AR	[99]
	3164 children aged 6–18 years	Adana (metropolitan)	ISAAC study questionnaires	13.6% AR	[100]

(continued)

Table 1 (continued)

Region/ Country	Population characteristics	Study location type	Study design/ method for assessing prevalence	% Prevalence of AR and/or AR/C (lifetime, unless stated otherwise)	Reference
	3040 children aged 6–15 years	Diyarbakir (urban)	ISAAC study questionnaires	12.9% AR and 39.9% AR within past 12 months	[101]
	2774 children aged 9–11 years	Ankara (metropolitan)	ISAAC study questionnaires	36.3% AR; 30.6% AR within past 12 months; 8.3% physician-diagnosed AR	[102]
	5412 children aged 7–12 years	Edirne (urban and rural)	Questionnaire	12.3% AR; 4.5% AR within past 12 months	[103]
	1366 children aged 13–18 years	Afyon (mountainous city)	ECRHS questionnaire	8.1% AR/C	[104]
	1515 university students	Eskisehir (urban)	ECRHS questionnaire	10.0% AR/C	[105]
	1336 adults aged ≥18 years	Manisa (urban)	ECRHS questionnaire	14.5% AR	[106]
	995 adults aged 20–44 years	Antalya (urban)	ECRHS questionnaire	22.7% AR	[107]
	465 subjects aged 16–64 years	Aydin (urban)	SFAR questionnaire and skin-prick tests	11.4% physician-diagnosed AR and 14% AR (skin-prick testing)	[108]
	4125 subjects aged 16–54 years	44 centres across Turkey (urban and rural)	Custom-designed questionnaire for AR	23.1% AR; 20.1% physician-diagnosed AR; and 23.8% self-reported AR in the urban and 18.4% in the rural areas in adult population	[109]

AR, allergic rhinitis; AR/C, allergic rhinoconjunctivitis; ATS-NHLI, American Thoracic Society-National Heart and Lung Institute questionnaire; ECRHS, European Community Respiratory Health Survey questionnaire; ISAAC, International Study of Asthma and Allergies in Childhood study; SFAR, score for allergic rhinitis questionnaire.

majority of these studies have also investigated the prevalence of disease in primarily children and demonstrated wide inter- and intra-regional differences. The lowest prevalence was noted in a cross-sectional study investigating a cohort of 737 secondary school students aged 12–20 years (mean age 16.4 years) in the city of San Bu, Guangdong, China [38]. Using standard questionnaires of respiratory and allergic symptoms and skin-prick testing for sensitization to common aeroallergens, the authors demonstrated that only 1.6% of the students documented a history of SAR within the past 12 months, despite a high prevalence of atopy (49% students were skin-prick test positive to one or more allergen). Indeed, a follow-up study 10 years later has indicated that the prevalence of SAR in San Bu was 2.1% compared with a prevalence of 15.7% in Hong Kong, despite high prevalence of atopy in both subpopulations [39]. Furthermore, sensitization to specifically mould was nearly 12-fold lower and to animal hair sixfold lower in San Bu than in Hong Kong, suggesting that sensitization to these agents may be important determinants for the manifestation of symptoms of AR. However, studies employing the standardized ISAAC study protocols have indicated that the prevalence of AR in Hong Kong children is even higher (ranging from 35% to 43%) [36, 42, 43] and similar to prevalence noted in 10–15-year-old children in central Taiwan [54]. Moreover, the ISAAC Phase III study has indicated that the prevalence of AR/C has increased all over the Asia-Pacific region over the last decade, with between 28.6 – 41.3% and 10.5 – 13.8% of children aged 6–14 years in the region reporting current nose symptoms and current AR/C, respectively [36].

Australia. A majority of studies investigating the prevalence of AR or AR/C in Australia have also concentrated predominantly on prevalence of disease in children [60–63], with one study documenting AR prevalence in adults [64]. The ISAAC studies in particular demonstrated prevalence of AR ranging from 12% to 20.8% in 4–14-year-old children [60–62], whereas in another study employing a children's respiratory questionnaire and skin-prick tests reported AR prevalence of 23.3% and 35.4% in Aboriginal and non-Aboriginal children, respectively [63]. The authors suggested that a parent with hayfever and atopy had strong risk factors for Aboriginal children but not for non-Aboriginal children. Overall, these findings are comparable with the ISAAC Phase III world map data for Australia, which showed 47.7% prevalence for hayfever ever and 19.3% prevalence for current AR/C in 13–14-year-old children and 19.8% prevalence for hayfever ever and

12.9% prevalence for current AR/C in 6–7-year-old children [36].

Eastern Europe (Russia). For the purpose of this paper, Russia was the only Eastern European country investigated, with the literature search showing relatively few studies to have investigated the prevalence of AR or AR/C in Russia [65–68]. An early ISAAC study comparing the prevalence of allergic diseases in 13–14-year-old children in Scandinavia and Eastern Europe demonstrated that prevalence of AR or AR/C in children in Eastern European was generally lower than in children in Scandinavia, with prevalence of 12.8% AR and 6.4% AR/C in Moscow being among the lowest of all the centres investigated [65]. The findings of relatively low prevalence of AR/C in Russia have been confirmed by a more recent ISAAC protocol-based study, which demonstrated prevalence rates of 15.2% vs. 8.8% AR and 4.7% vs. 3.2% AR/C in 7–16-year-old schoolchildren in the towns of Imatra in Finland and Svetogorsk in Russia on either side of the common border [66].

Latin America. Studies investigating the prevalence of AR or AR/C in children in Latin America have also mostly employed the ISAAC protocol [69–76]. Earlier studies from Brazil and Mexico demonstrated that prevalence of AR or AR/C ranged from 4.7% AR in 6–8-year-old children in Juarez, Chihuahua, Mexico [76] to 28.5% AR/C in 13–14-year-old children in Rio Grande do Sul, Brazil [70]. A more recent ISAAC Phase III study has evaluated the prevalence of rhinitis-related symptoms in 6–7-year-old children from 35 centres in 14 Latin American countries and in 13–14-year-old children from 56 centres in 17 Latin American countries [69]. The authors demonstrated that for the 6–7-year-old group, the mean prevalence for current AR/C was 12.7% and ranged from 5.5% in Rosario City (Argentina) to 20.4% in Caracas (Venezuela). Similarly, for the 13–14-year adolescent group, the mean prevalence of current AR/C was 17.3% and ranged from 7.1% in Cuernavaca (Mexico) to 45.1% in Asunción (Paraguay). Overall, the prevalence of rhinitis-related symptoms was higher among the Spanish speaking centres, and the rates of current AR/C noted were among the highest in the world observed during ISAAC Phase III studies [36].

Middle East. To date studies of prevalence of AR or AR/C from the Middle East countries have been conducted mostly in schoolchildren aged 6–14 years, employing appropriately translated versions of the standardized ISAAC study protocol [77–91]. These studies have also shown a wide variation in the prevalence of AR among children in different countries in the region, ranging from a nationwide AR prevalence of 7.4% in 6–7-year-old children in Oman [85] to a lifetime AR prevalence of 45.2% in 13–15-year-old children from several provinces in Lebanon [82]. Comparison of data from the more recent studies with those from the earlier studies further suggests that prevalence of AR has increased substantially, nearly doubling in certain regions of Lebanon [82, 84] and the UAE [89, 90], over the region during the last decade.

Turkey. The prevalence of AR or AR/C has been investigated in a large number of studies conducted in different regions of the country [92–109], with the majority investigating prevalence of disease in children using the standardized ISAAC study [92–102]. Studies employing the ISAAC study protocol have indicated the prevalence of AR in children aged 6–18 years to range from 2.9% in Sanliurfa, a socio-economically deprived city with high rates of infectious and parasitic diseases and hot dry climate, in south-eastern Turkey [98] to 37.7% in Zonguldak, a highly industrialized city with high usage of unrefined coal without domestic or industrial air-filtrating systems, in north-west Turkey [99]. Indeed, other studies have also indicated that the prevalence of AR in children is also high (>30%) in other well-developed and industrialized/polluted cities such as Ankara [102] and Izmir [97] in western Turkey and comparatively low ($\leq$10%) in agriculturally rich areas such as Afyon in central-west Turkey [104].

Prevalence in adults

No suitable studies were selected for review of prevalence of AR or AR/C in adults in Africa, Latin America or the Middle East, although there were some reports from the other regions of interest.

Asia-Pacific. Few studies have reported the prevalence of AR or AR/C in adults in the Asia-Pacific region. A population-based study assessing self-reported AR by validated questionnaires-based telephone interviews in over 38 000 subjects in 11 major cities in China recently demonstrated that the prevalence of AR, after adjusting for age and gender, was highly variable and ranged from 8.7% in Beijing in east China to a 24.1% in Urumqi in west China [41]. Importantly, this study further demonstrated that of the subjects with self-reported AR, 74.4% were diagnosed as having intermittent AR and 25.6% persistent AR according to the new ARIA classification [9], with pollen (47.8%), animal dander (26.2%) and dust mites (19.8%) being the most common sensitizing agents. Similarly, a population-based study involving a stratified cluster disproportionate random sample of 2868 adults aged 20–74 years selected from five housing estates in Singapore has demonstrated a mean AR prevalence rate of 5.5%, with males, subjects of Indian and Chinese origin, and those with higher socio-economic status being more affected [52]. Other local questionnaire-based studies have reported self-reported AR prevalence rates of up to 35.5% in Japan [46] and 16.4–24.7% in Korea [49].

Australia. One longitudinal study has investigated the prevalence of self-reported AR in a population-based cohort of adults in Australia, using a questionnaire [64]. Using a stratified random sample, the authors demonstrated that prevalence for hayfever was more than doubled from 19.2% in 1968 to 41.3% in 1991–1993.

Eastern Europe (Russia). Similarly, one self-administered local questionnaire-based study has investigated the prevalence of AR or AR/C in Russia and indicated that the prevalence of AR may be comparatively low in adults [68]. Comparison of the prevalence of atopic diseases among about 4500 adults in two geographically related arctic areas, Nikel a heavily polluted town in Russia and Sør-Varanger a non-polluted town in Norway, demonstrated that the lifetime prevalence of atopic diseases was significantly lower in Nikel than in Sør-Varanger, with the prevalence of AR being 5.6% Nikel and 10.3% in Sør-Varanger ($P < 0.001$). The authors suggested that the low prevalence of AR in Nickel was at least partly due to the low standard of living and dwelling in smaller well ventilated but poorly insulated flats/houses, compared to those commonly found in Western Europe.

Turkey. A few studies have investigated the prevalence of AR in Turkish adults [106–109], using the standardized European Community Respiratory Health Survey (ECRHS) [106, 107] and score for allergic rhinitis (SFAR) [108] questionnaires. These were primarily population-based studies and demonstrated that the prevalence of AR in adults ranged from about 14.0% to 22.7% [106–108]. In a more recent population-based study, Cingi and colleagues [109] assessed the prevalence of AR in the Turkish adult population across seven distinct geographical regions in Turkey, using a custom-designed questionnaire with particular emphasis on descriptive parameters. After adjusting for errors, data from 4125 volunteers indicated that the prevalence of self-reporting AR and physician-diagnosed AR ranged from 16.3% and 15.7%, respectively, in the Eastern Anatolia region to 27.5% and 23.4% in the Marmara region. The overall mean prevalence of self-reporting AR and physician-diagnosed AR was 23.1% (men 22.3%, women 23.8%) and 20.1% (men 19.7%, women 20.4%), respectively. Moreover, based on the ARIA classification, the mean prevalence of persistent AR was found to be 8.1% in men and 9.1% in women, and the mean prevalence of intermittent AR 14.2% and 14.7% in men and women, respectively.

Global prevalence of AR/C in children aged 6–14 years

A comprehensive ISAAC Phase III study involving over a million children aged from 6 to 14 years from all the major regions of the world has recently demonstrated that the overall mean global prevalence of current AR and AR/C symptoms in children aged 13–14 years was 31.7% and 14.6%, respectively, and ranged from 4.2% and 1.0% in a centre in India to 80.6% and 45% in a centre in Paraguay, respectively [36]. There was also substantial regional variation in the prevalence of AR/C symptoms (range 10.7% in the Indian sub-continent to 18% in Africa; followed closely by 17.3% in Latin America) and between countries and centres within the different regions, with the highest prevalence being observed particularly in centres from the middle and low income countries in Africa and Latin America. Similarly, in children aged 6–7 years, the overall mean global prevalence of current AR and AR/C symptoms was 21.4% and 8.5%, respectively, and ranging from 6.3% and 4.2% in the Indian sub-continent to 46.6% and 12.7% in Latin America, respectively. As for data for the older children, large variations were observed in prevalence of AR/C symptoms between regions, countries and centres. Moreover, assessment of prevalence according to the gross national income of the country demonstrated that prevalence of current nose symptoms, current nose and eye symptoms and current rhinoconjunctivitis symptoms in the younger children was about 1.5- to 2-fold higher in the middle and high income countries than in the low income countries, whereas in the older children the variations were not as marked (Fig. 3) [36]. Further assessment of data from this study in terms of latitude, however, suggests that the prevalence of rhinitis and ocular symptoms in children may be significantly higher in the tropical regions compared with the temperate regions (Table 2). Although the reasons for these trends are not presently clear, it is possible that climatic factors may play a role in the development of allergic disease in these regions. This, however, needs to be confirmed in large studies specifically designed to estimate the prevalence of AR in regions with different climates.

Limitations of studies investigating prevalence of AR or AR/C

It is clear that comparison of the prevalence or incidence of disease in different populations and sub-populations is particularly difficult when there is little or no uniformity in the methodologies employed. In this regard it is likely that the wide variation in prevalence of allergic diseases (including AR, AR/C, asthma and eczema/dermatitis) noted in these studies was at least in part due to differences in the instruments employed to assess prevalence such as the ISAAC study questionnaire, the ECRHS questionnaire, the Middleton diary symptom questionnaire and questionnaires standardized to local/national levels that have also been employed in other studies. Moreover, some studies evaluated the prevalence of allergic disease on the basis of observational surveys, telephone interview surveys, self-reported symptoms and the degree of skin-prick test reactivity and/or presence of specific IgE antibodies to agents inducing the symptoms of AR or AR/C in individuals potentially predisposed to allergic disease. The difficulty in assessment is likely to be further compounded by measurement/expression of

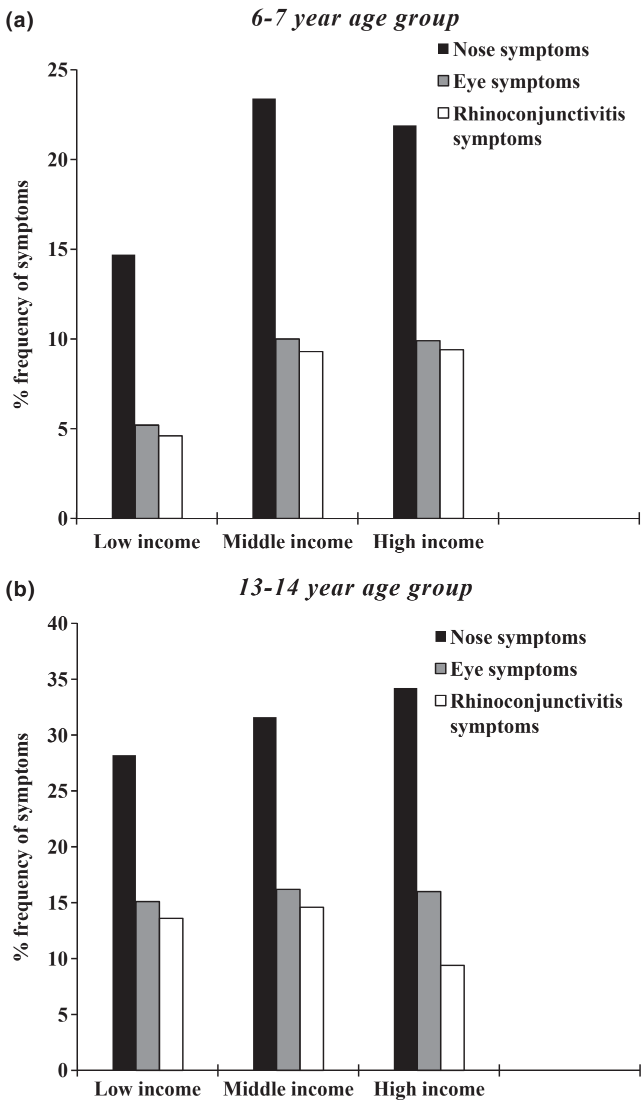

Fig. 3. Prevalence of symptoms by level of gross national income in children aged (a) 6–7 years and (b) 13–14 years (modified from Aït-Khaled et al. [36]).

prevalence as questionnaire-based or doctor or physician-diagnosed cumulative (lifetime) prevalence, questionnaire-based or physician-diagnosed prevalence of AR in the past 12 months or just self-symptoms reported prevalence. Not least of all, it is possible that patients with vasomotor rhinitis/non-AR may be captured within these data, particularly as several studies have reported prevalence of rhinitis in the absence of data on specific allergens/sensitizing agents, as shown in Table 3.

Pattern of allergens and risks associated with allergic disease

Several studies have documented the allergens/sensitizing agents and risk factors associated with the increased prevalence of AR and AR/C in the regions of interest [26, 30, 35, 37–39, 42, 45–50, 50–59, 63, 66, 68, 71, 72, 79, 81, 82, 86, 89, 92, 93, 95, 97, 103, 110–165].

Allergens and sensitizing agents

Not surprisingly, wide varieties of grass/tree pollen and/or mites are present in the different regions and play an important role as traditional sensitizing allergens in the development of AR in these regions (Table 3). Despite the presence of the large numbers of

Table 2. Prevalence of symptoms by latitude (modified from Aït-Khaled et al. [36])

	n	Mean	SD	Median	IQR	*P*-value (Mann–Whitney)
Total rhinitis						
Global	230	31.06	10.96	31.65	14.85	
Tropics	87	32.90	13.47	33.40	17.6	0.261 vs. sub-tropics
Sub-tropics	75	31.00	9.75	31.00	14.2	0.243 vs. temperate
Temperate	68	28.82	7.93	31.50	13.4	0.028 vs. tropics
Rhinitis with eye symptoms						
Global	230	15.76	6.80	15.40	9.13	
Tropics	87	16.90	7.95	16.20	12.4	0.675 vs. sub-tropics
Sub-tropics	75	16.42	6.22	15.90	8.6	0.012 vs. temperate
Temperate	68	13.56	5.23	14.10	8.98	0.008 vs. tropics
% Eye symptoms of total rhinitis						
Global	230	50.48	12.97	51.12	14.92	
Tropics	87	51.44	14.12	51.35	17.66	0.502 vs. sub-tropics
Sub-tropics	75	52.91	12.03	52.47	13.32	0.004 vs. temperate
Temperate	68	46.57	11.64	48.54	15.1	0.035 vs. tropics

these allergens, regional assessment of these agents suggests that there may be some general sensitizing patterns. Thus, while the 'pollen allergens' appear to be important sensitizing allergens in Australia, the Middle East countries, Southern Africa and Turkey, the 'mite and cockroach allergens' appear to be important sensitizing agents in Asia-Pacific region. Although the very large diversity and overlapping types of grass, tree and weed pollen makes it virtually impossible to assign specific plants as the main causes of AR in the different regions, it does nevertheless appear that Salsola and other weed pollen are particularly important sensitizing agents in the Middle East [154–158, 161], where as cereal pollen appear to be important sensitizers in Turkey [164–166]. Although, a large number of studies from Japan suggest Japanese cedar pollen to be possibly the most prevalent and important sensitizing agents across Japan [45–66, 118–122, 124, 126], other studies have indicated that Japanese birch and cypress pollen are also important in different parts of Japan [116, 124, 126]. Similarly, there is some evidence that sensitization to the non-traditional silk/silk worm allergens may be important in the aetiology of AR particularly in China [114] and Japan [126]. Indeed, in a population-based study examining the relationship between asthma, AR and skin test reactivity to aeroallergens in over 10 00 subjects in the province of Anqing in China, Celedón and colleagues [114] demonstrated that sensitization to dust mite and sensitization to silk were independent predictors of rhinitis.

'Conventional' risk factors

Assessment of the risk factors associated with the development of AR and AR/C in these regions has indicated the involvement of a variety of both conventional and non-conventional risk factors. The conventional risk factors, including genetic pre-disposition to allergic disease and sensitization to grass/tree/weed pollen and/or dust mite allergens have been shown to be important determinants of AR and AR/C in all regions investigated.

'Non-conventional' risk factors

Non-conventional risk factors, such as 'improved' dwellings [68, 72, 92, 95, 97, 102, 132] and exposure to fossil fuel and traffic related pollutants [57, 58, 82, 95, 102, 121, 129, 130], which are often associated with increased socio-economic status of individuals, were increased in the more affluent countries and affluent regions within these countries. It is likely that improvement in indoor environment/lifestyle/affluence results in more time being spent indoors leading to perennial and greater exposure to more indoor allergens and subsequently to changes in sensitization patterns [166]. Indeed, evidence from the last few decades suggests that increased dampness and poor ventilation caused by tight insulation of modern homes has increased sensitization and allergy to mould [167–169], a finding that is consistently observed in several countries reviewed herein [59, 102, 132, 136, 139, 145, 146, 152, 162]. Moreover, one study has suggested that dampness in the home may be one of the most important risk factors in the development of respiratory symptoms in subtropical areas [170].

Furthermore, as indicated by many studies in the present review, other studies have indicated that a large number of individuals are sensitized to multiple indoor and outdoor antigens [166]. It is possible that polysensitization and cross-reactivity among the antigens may result in manifestation of more persistent and severe symptoms of AR and AR/C in affected individuals [166]. Although the association between fossil fuel-derived air pollution and the increased prevalence of AR or AR/C has not been demonstrated unequivocally, a growing body of evidence suggests that increased air pollution may lead to increased risk of allergic sensitization [130, 171–173].

Although the situation for assessment of risk factors for AR is complicated enough under normal circumstances, due to the demonstration of a host of conventional and non-conventional risk factors, this is further compounded by the findings of a recent study, which suggest that in patients with co-morbid AR and asthma the assignment of risk factors may depend on how AR is defined [174]. In a cross-sectional study of 616 Costa Rican children aged 6–14 years with asthma, Bunyavanich and colleagues [174] demonstrated that in a multivariate analysis of risk factors, when AR was defined on the basis of ≥ 1 skin test reaction-positive results to allergens for AR (STR-positive AR), the presence of nasal symptoms after exposure to dust or mould, parental history of AR, older age at asthma onset, oral steroid use in the past year, eosinophilia and positive specific IgE to dust mite and cockroach were all found to be independent risk factors of STR-positive AR, with significantly increased adjusted odds ratios (ORs; ranging from 2.0 for oral steroid use in past year to 17.2 for positive specific IgE for dust mite; $P < 0.05$ to $P < 0.0001$). However, when AR was defined based on physician-diagnosed AR, the adjusted ORs were significantly increased for nasal symptoms after pollen exposure, skin test reactivity to tree pollen, parental history of AR, inhaled steroid and short-acting β_2-agonist use in the past year, and household mould/mildew (OR ranging from 1.6 [$P < 0.02$] for household mould/mildew to 2.4 ($P < 0.0001$) for inhaled steroid in last year. In contrast the OR for presence of ≥ 3 siblings was significantly decreased (OR = 0.4[95% CI: 0.2–0.8]; $P < 0.008$). Moreover, the prevalence of AR was also

Table 3. Studies documenting allergens/sensitizing agents and/or risk factors for allergic rhinitis (AR) and allergic rhinoconjunctivitis (AR/C) in diverse and developing regions around the world

Region/country	Allergen/sensitizing agents investigated	Risk factors for AR or AR/C	Reference
Africa			
Egypt	Not documented	Education at a state school, father's education, parental history of asthma/AR symptoms	[26]
Mozambique	Not documented	Urban/semi-urban dwelling	[30]
South Africa	Latex	Sensitization to latex increased risk for AR/C	[111]
Zimbabwe	*Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*; Bermuda grass, and weeds (plantain), cats, mould	Sensitization to dust mites, Bermuda grass, and weeds (plantain)	[35]
Intertropical zone Africa	Cockroaches, mites; moulds	Cockroach sensitization ranked second, after mites, in inducing AR symptoms	[111]
Asia-Pacific			
China and Hong Kong	Dust mite, cockroach; grasses (rye grass, couch grass, Kentucky blue, orchard, redtop, timothy, sweet vernal, meadow fescue, perennial rye); moulds	Atopy, sensitization to cockroach and dust mite; parental history of hayfever/wheezing, frequent URTI, male gender; birth in Hong Kong	[37–39, 42]
	D. farinae/pteronyssinus, American cockroach, *Blomia tropicalis*, *Blatella germanicus*; mixed grass and tree pollens; *Artemisia vulgaris*, *Ambrosia artemisiifolia*, cat, dog, mould	AR severity significantly correlated with degree of skin test reactivity to *A. vulgaris*, *A. artemisifolia*, *D. pteronyssinus, D. farinae* and *B. tropicalis*	[112, 113]
	D. farinae/pteronyssinus, cockroach; mixed grass and tree pollen; mould and silk	Sensitization to silk an independent predictor of rhinitis	[114]
	Trees (Cedar, cypress, juniper) and grass (*Rye-Lolium multiflorum*, Bermuda, orchard, Timothy, Johnson, Oat/wild Oats, Velvet) pollens	Chinese and other non-Caucasians (Filipino and Japanese) more sensitive and reactive to grass and tree pollens than Caucasians	[115, 116]
Japan	Dust mites; Japanese cedar (*Cryptmeria japonica*; CJ) pollen; grass pollens; mould	Month of birth and family history of allergic disease, residence along a main street; mount of airborne pollen predictive of symptom severity	[45, 46, 117]
	Dust mites; Japanese cedar pollen	Strong sensitization to Japanese cedar pollen associated with age, the amount of dispersed pollen in the observed year and in the year following birth, and the month of birth; vehicle related air pollution	[118–121]
	Japanese cedar pollen	Cat ownership and passive smoking associated with a lower prevalence of AR and cedar pollinosis	[122]
	Dust mites; *Plantago lanceolata* (English plantain) pollen, birch pollen, Japanese cedar pollen, cypress pollen, Olive tree (*Olea europaea*) pollen; orchard grass, timothy, mugwort, ragweed, sage brush, dandelion; silkworm moth, midge, cat, Alternaria	*P. lanceolata*; olive pollen and silkworm allergens important cross-reacting/sensitizing agents of AR in Japan, whereas birch pollen associated with allergies to some foods	[50, 123–126]
Korea	Citrus red mite (*Panonychus citri*), two-spotted spider mite (*Tetranychus urticae*), *D. pteronyssinus, D. farinae*, and cockroach	Working in citrus farms and rural dwelling associated with significant sensitization to citrus red mite and spider mite in subjects with AR	[47–50, 50, 127]
	Dust mites, cockroach, cat, grass/weed/tree pollens	Sensitization to indoor allergens (HDM and cockroach) more common in Seoul, whereas sensitization to grass pollen more common in Ankara	[128]
Malaysia	Dust mite, cockroach; grass pollens; moulds	Atopy, sensitization to cockroach and dust mite	[39]
Philippines	Trees (Cedar, cypress, juniper) and grass (*Rye-Lolium multiflorum*, Bermuda, orchard, Timothy, Johnson, Oat/wild Oats, Velvet) pollens	Filipino and other non-Caucasian groups (Chinese and Japanese more sensitive to cedar, cypress and juniper pollen than Caucasians	[116]

(continued)

Table 3 (continued)

Region/country	Allergen/sensitizing agents investigated	Risk factors for AR or AR/C	Reference
Singapore	Dust mites, grass/tree pollens, dog, cat, birds, medicines	Males gender, younger age, Indian/Chinese ethnicity, and higher socio-economic status, associated with increased prevalence of AR	[52]
Taiwan	*D. pteronyssinus*, *Blatella germanica*, cat, dog, *Aspergillus fumigatus*, *Candida albicans*	Male gender, young age (6–12 years), infectious disease, exposure to traffic-related air pollutants (CO, NOx and O_3) significant risk factors for AR or AR/C	[54–58, 129–131]
	D. pteronyssinus; *D. farinae, B. germanica*, cockroach, cat, dog, *A. fumigatus*, *C. albicans*	Sensitization to both indoor and outdoor allergens; including cockroach and mould, and stuffed toys associated with increased allergic disease	[131–133]
Thailand	House-dust mites, cockroach, dog, cat, mould, Bermuda grass, para grass, sedge, and careless weed pollen	Sensitization to both indoor and outdoor allergens, but not mould, associated with increased prevalence of allergic disease	[59]
Australia	*D. pteronyssinus*, rye grass pollen, *Alternaria alternata*	Parent with hayfever, but not atopy, strong risk factor for Aboriginal children, but not for non-Aboriginal children	[63]
	D. pteronyssinus, rye grass pollen	Early life viral URI and ryegrass allergen exposure associated with ryegrass sensitization and hayfever symptoms. Fish intake decreased risk of sensitization to ryegrass, but not to HDM	[135, 136]
	Dust mites, cockroach, grass (rye, Tibouchina, Bahia, Bermuda grass) and ragweed pollens, moulds	Sensitization to ragweed, Tibouchina and Bermuda grass and exposure to Alternaria spores important for AR and AR/C	[137, 138]
	Dust mites, grass pollen, Ascaris antigens	Prevalence of AR strongly associated with length of stay of Asian migrants in Australia, compared with Australian-born Asians and non-Asians	[139]
	Dust mites, grass pollen	Sensitization to grass pollen higher in inland areas and to HDM higher in the coastal areas	[140]
Eastern Europe			
Russia	Not documented	Parental history of asthma, smoking and indoor dampness associated with significant increased risk, and respiratory infections with decreased risk of AR or AR/C	[66, 68]
Latin America			
Argentina	Dust mites, grass/weed/tree pollen, soya bean	Soybean sensitization leads to more severe symptoms of AR	[141]
Brazil	Not documented	Males gender, education in private schools, higher socio-economic status risk factors for increased AR	[71, 72]
	D. pteronyssinus, *D. farinae*, *B. tropicalis*, *Lolium multiflorum* (Lm) grass, grass mix	LM is a major cause of pollinosis in Southern Brazil	[143, 144]
	D. pteronyssinus, B. germanica, Periplaneta americana, grass mix, dog, cat, fungal mix	Sensitization to more than one allergen is significantly associated with asthma and rhinitis	[145, 146]
	D. pteronyssinus, D. farinae, B. tropicalis, B. germanica, P. americana, Fungal/mould mix, cat, dog	B tropicalis and cockroach important cross-reacting allergens (with mite and food allergens) in patients with AR	[147, 148]
Costa Rica	*D. farinae, D. pteronyssinus*, cockroach, mixed grass pollen, Alternaria, cat	Sensitization to HDM and cat dander significantly associated with AR	[149]
Mexico	Carya, Celtis, Cupressus, Fraxinus and *Pinus pollen*	Airborne Fraxinus and Cupressus pollens important allergens in metropolitan Monterrey Nuevo Leon	[150]

(continued)

Table 3 (continued)

Region/country	Allergen/sensitizing agents investigated	Risk factors for AR or AR/C	Reference
Venezuela	*B. tropicalis, D. pteronyssinus*	*B. tropicalis* an equally important sensitizing agent as *D. pteronyssinus* in Venezuela	[151]
	Fungal mix	PAR severity associated with indoor fungal load	[152]
Middle East			
Iran	Mites, grasses, weeds (*Salsola kali*, *Fraxinus americana*), moulds	*S. kali* and/or *F. americana* weed pollens important allergens for AR in Iran	[154]
Israel	Not documented	Family history, ethnicity, smoking among mothers major risk factors among Jewish schoolchildren	[79]
	O. europaea (olive) pollen	Sensitization to olive pollen directly proportional to number of olive trees in the Jewish population, but low in Arab population despite high density of trees	[155]
Kuwait	*D. pteronyssinus*; American/German cockroach, Salsola, *Chenopodium album*, Bermuda grass, Aspergilus mix, Cladosporium mix	Sensitization most frequent and strongest to Salsola pollen, compared with indoor allergens	[156]
	Chenopodiaceae and Amaranthaceae weed pollens; grass pollens (Gramineae), fungi spores	Number of new AR patients highly correlated with mean total pollen count of seasonal Chenopodiaceae and Amaranthaceae pollen	[157]
Lebanon	Not documented	Living in busy areas of South and North Lebanon increased risk of AR	[82]
Qatar	*D. pteronyssinus*, *D. farinae*, cockroach, grass/tree pollens, insects, moulds, yeast	Male gender, sensitization to house dust mites and cockroach high risk factors	[86, 158]
Saudi Arabia	*D. pteronyssinus*, Bermuda grass, reed (*Phragmites communis*), cat/rat/goat hair, mould	Bermuda grass is the most common sensitizing allergen leading to PAR in eastern Saudi Arabia	[159]
United Arab Emirates	Not documented	Family history of AR, Arab origin, younger age, female gender and higher education high risk factors for AR	[90]
	D. pteronyssinus, *D. farinae*, *B. germanica*; *Cynodon dactylon*/*S. kali*/*Prosopis juliflora* pollen; cat	Grass and weed pollen are the most prominent sensitizing allergens in the UAE	[160]
Turkey	Not documented	Family history of atopy/disease, living in shanties, frequent RTIs, antibiotics use in the first year of life independent risk factors for AR	[92, 93, 95]
	D. pteronyssinus, *D. farinae*; *B. germanica*; grasses (*Holcus lanatus, Dactylis glomerata, Lolium perenne, Phleum pratense, Poa pratensis, Festuca pratensis, Avena eliator*); trees (*Betula verrucosa, Fagus silvatica*, Quercus alba/robur, *Platanus orientalis, Ulmus americana*, Salix, Populus, *O. europaea*); mixed weeds (*A. vulgaris*, Chenopodium, Plantago, *S. kali*); moulds, fungi	Family history of atopy (self or either parent), female gender, indoor heating with gas stove, dampness or moulds in the first year of life independent risk factors for AR	[97, 102, 106, 108]
	Mites, cockroaches, salicaceae, betulaceae and fagaceae tree pollens, weed pollen, fungus	Betulaceae and fagaceae allergies most common, despite salicaceae being most the prominent pollen	[161]
	D. pteronyssinus, *D. farinae*; barley/maize/oat/wheat pollens; moulds (*Altenaria alternate*)	*Altenaria alternate* single most sensitizing allergen in Istanbul, followed by *D. farinae*, *D. pteronyssinus*, and a mix of four cereals (barley, maize, oat, wheat)	[162]
	D. pteronyssinus, *D. farinae*; cockroach; Gramineae pollens; grass pollens, arboreal and non-arboreal tree pollens; weed pollens	Grass cereal (Gramineae) pollens major sensitizing agents in Ankara and Eskisehir, although the trees and weeds also play a substantial role	[163, 164]

noted to be substantially different based on these definitions of AR; 80% prevalence was based on positive skin test reactive results, compared with 27% prevalence for physician-diagnosed AR. As a substantial proportion of patients with asthma or AR have comorbid AR or asthma, respectively [9, 175, 176], these findings are likely to be of particular relevance for clinicians, healthcare workers and economists alike, involved in developing and implementing global management strategies for AR.

Summary and recommendations

This review has demonstrated that the prevalence of AR or AR/C varies greatly within and between Africa, the Asia-Pacific region, Eastern Europe, the Middle East, South America and South East Asia. Our findings suggest that the greater diversity in prevalence of AR or AR/C in populations in these regions is in contrast to the lower diversity of AR or AR/C in the western populations (United States and Europe), which tend to be more uniform (Fig. 2). Furthermore, this review provides a comprehensive database of the important allergens and triggers which are likely to influence the prevalence of AR in these diverse regions, where the prevalence of AR is increasing and its adverse impact on the quality of life of affected individuals is increasingly recognized. Although there is a little doubt that the use of different instruments and different outcome measures, as well as a host of both conventional and non-conventional risk factors, is likely to have contributed to the large variations in the prevalence of AR or AR/C noted within these regions, some interesting patterns are nevertheless apparent. It is particularly notable that affluence and the improvements in education and living standards associated with this affluence in some of the African countries, 'China-Hong Kong-Taiwan', and several Middle East countries have coincided with marked increase in the prevalence of AR and or AR/C in these countries. It is likely that the overall influence of improvements in living standards in these regions has been to increase exposure to a variety of indoor risk factors and therefore increase prevalence of symptoms of AR or AR/C, similar to that noted for the developed westernized countries in Europe and North America.

In conclusion, this review has clearly identified some important areas for consideration in future studies. In particular, these need to be more standardized, particularly with regard to ocular symptoms and cover both adults and children (in contrast to ISAAC). Furthermore, there is a need for a validated questionnaire for ocular symptoms, not just 'itchy eyes' tagged onto AR questions, as well as a consensus on how and over what time span AR and AR/C incidence should be surveyed, i.e. doctor-diagnosed or self-reported symptoms and current, over last 12 months or ever. In view of the findings for sensitization to multiple antigens, and therefore the possibility of coincidental persistent and more severe symptoms of AR and increased incidence of comorbidity with asthma, it is likely also that a different treatment approach may need to be adopted for the management of these individuals. In the first instance, patients would need to be tested for sensitization to a much larger number of traditional and non-traditional triggers as appropriate in the region, followed by a more specific patient-tailored pharmacologic treatment strategy for individuals who become sensitized and develop AR much later in life. In this regard, it is likely that 'AR control' needs to be defined more precisely, analogous to that available for asthma [177], in order that treatment can be optimized for individual patients. Although this is clearly a task requiring global consensus and approval, in the interim development of a simple and modified version of the Rhinitis Control Assessment Test [178], which assesses AR control to only a certain degree, may provide a more practical means for assessment on AR control in daily clinical practice.

Acknowledgements

The authors would like to thank GlaxoSmithKline for convening the group and providing financial support for two meetings in February and June of 2010, during which the manuscript was developed. Financial support comprised of author's airfare, ground transportation at meeting venue and hotel accommodation. The authors wish to acknowledge Dr Jagdish Devalia for assistance in the preparation and editing of this article.

References

1 Canonica GW, Bousquet J, Mullol J, Scadding GK, Virchow JC. A survey of the burden of allergic rhinitis in Europe. *Allergy* 2007; **62**(Suppl. 85):17–25.

2 Schatz M. A survey of the burden of allergic rhinitis in the USA. *Allergy* 2007; **62**(Suppl. 85):9–16.

3 Schoenwetter WF, Dupclay L, Appajosyula S, Botteman MF, Pashos CL. Economic impact and quality of life burden of allergic rhinitis. *Curr Med Res Opin* 2004; **20**:305–17.

4 Reed SD, Lee TA, McCrory DC. The economic burden of allergic rhinitis. *Pharmacoeconomics* 2004; **22**:345–61.

5 Nathan RA. The burden of allergic rhinitis. *Allergy Asthma Proc* 2007; **28**:3–9.

6 Blaiss MS. Pediatric allergic rhinitis: physical and mental complications. *Allergy Asthma Proc* 2007; **29**:1–6.

7 Meltzer EO, Blaiss MS, Derebery MJ *et al.* Burden of allergic rhinitis: results from the Pediatric Allergies in America survey. *J Allergy Clin Immunol* 2009; **124**(3 Suppl.):S43–70.

8 Meltzer EO, Nathan R, Derebery J *et al.* Sleep, quality of life, and productivity impact of nasal symptoms in the United States: findings from the Burden of Rhinitis in America survey. *Allergy Asthma Proc* 2009; **30**:244–54.

9 Bousquet J, Khaltaev N, Cruz AA *et al.* Allergic rhinitis and its impact on asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA^{2}LEN and AllerGen). *Allergy* 2008; **63**(Suppl. 86):8–160.

10 Bousquet J, Bodez T, Gehano P *et al.* Implementation of guidelines for allergic rhinitis in specialist practices. A randomized pragmatic controlled trial. *Int Arch Allergy Immunol* 2009; **150**:75–82.

11 Bousquet J, Lund VJ, van Cauwenberge P *et al.* Implementation of guidelines for seasonal allergic rhinitis: a randomised controlled trial. *Allergy* 2003; **58**:733–41.

12 Long A, McFadden C, DeVine D, Chew P, Kupelnick B, Lau J. *Management of allergic and nonallergic rhinitis.* Evidence report/technology assessment No. 54 (Prepared by New England Medical Center Evidence-based Practice Center under Contract No. 290-97-0019). AHRQ Pub. No. 02-E024. Rockville, MD: Agency for Healthcare Research and Quality, May 2002.

13 Bauchau V, Durham SR. Prevalence and rate of diagnosis of allergic rhinitis in Europe. *Eur Respir J* 2004; **24**:758–64.

14 Bachert C, van Cauwenberge P, Olbrecht J, van Schoor J. Prevalence, classification and perception of allergic and nonallergic rhinitis in Belgium. *Allergy* 2006; **61**:693–8.

15 Nathan RA, Meltzer EO, Derebery J *et al.* The prevalence of nasal symptoms attributed to allergies in the United States: findings from the burden of rhinitis in an America survey. *Allergy Asthma Proc* 2008; **29**:600–8.

16 Ceuppens J. Western lifestyle, local defenses and the rising incidence of allergic rhinitis. *Acta Otorhinolaryngol Belg* 2000; **54**:391–5.

17 Asher MI, Montefort S, Björkstén B *et al.* Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC phases one and three repeat multicountry cross-sectional surveys. *Lancet* 2006; **368**:733–43.

18 Galassi C, De Sario M, Biggeri A *et al.* Changes in prevalence of asthma and allergies among children and adolescents in Italy: 1994-2002. *Pediatrics* 2006; **117**:34–42.

19 Liao MF, Liao MN, Lin SN, Chen JY, Huang JL. Prevalence of allergic diseases of schoolchildren in central Taiwan. From ISAAC surveys 5 years apart. *J Asthma* 2009; **46**:541–5.

20 Björkstén B, Clayton T, Ellwood P, Stewart A, Strachan D; ISAAC Phase III Study Group.Worldwide time trends for symptoms of rhinitis and conjunctivitis: phase III of the International Study of Asthma and Allergies in Childhood. *Pediatr Allergy Immunol* 2008; **19**:110–24.

21 World Health Organisation. Global surveillance, prevention and control of chronic respiratory diseases – a comprehensive approach. In: Jean B, Nikolai K, eds. World Health Organisation (WHO), 2007. Available at http://www.who.int/gard/publications/chronic_respiratory_diseases.pdf (accessed 16 September 2010).

22 Asher MI, Keil U, Anderson HR *et al.* International study of asthma and allergies in childhood (ISAAC): rationale and methods. *Eur Respir J* 1995; **8**:483–91.

23 Weiland SK, Björkstén B, Brunekreef B *et al.* Phase II of the International Study of Asthma and Allergies in Childhood (ISAAC II): rationale and methods. *Eur Respir J* 2004; **24**:406–12.

24 Ellwood P, Asher MI, Beasley R, Clayton TO, Stewart AW; the ISAAC Steering Committee. The International Study of Asthma and Allergies in childhood (ISAAC): phase Three rationale and methods. *Int J Tuberc Lung Dis* 2005; **9**:10–6.

25 Ait-Khaled N, Odhiambo J, Pearce N *et al.* Prevalence of symptoms of asthma, rhinitis and eczema in 13- to 14-year-old children in Africa: the International Study of Asthma and Allergies in Childhood Phase III. *Allergy* 2007; **62**:247–58.

26 Georgy V, Fahim HI, El-Gaafary M, Walters S. Prevalence and socioeconomic associations of asthma and allergic rhinitis in northern Africa. *Eur Respir J* 2006; **28**:756–62.

27 Hailu S, Tessema T, Silverman M. Prevalence of symptoms of asthma and allergies in schoolchildren in Gondar town and its vicinity, northwest Ethiopia. *Pediatr Pulmonol* 2003; **35**:427–32.

28 Esamai F, Anabwani GM. Prevalence of asthma, allergic rhinitis and dermatitis in primary school children in Uasin Gishu district, Kenya. *East Afr Med J* 1996; **73**:474–8.

29 Bouayad Z, Aichane A, Afif A *et al.* Prevalence and trend of self-reported asthma and other allergic disease symptoms in Morocco: ISAAC Phase I and III. *Int J Tuberc Lung Dis* 2006; **10**:371–7.

30 Mavale-Manuel S, Joaquim O, Macome C *et al.* Asthma and allergies in schoolchildren of Maputo. *Allergy* 2007; **62**:265–71.

31 Falade AG, Olawuyi JF, Osinusi K, Onadeko BO. Prevalence and severity of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema in 6- to 7-year-old Nigerian primary school children: the international study of asthma and allergies in childhood. *Med Princ Pract* 2004; **13**:20–5.

32 Falade AG, Olawuyi F, Osinusi K, Onadeko BO. Prevalence and severity of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema in secondary school children in Ibadan, Nigeria. *East Afr Med J* 1998; **75**:695–8.

33 Zar HJ, Ehrlich RI, Workman L, Weinberg EG. The changing prevalence of asthma, allergic rhinitis and atopic eczema in African adolescents from 1995 to 2002. *Pediatr Allergy Immunol* 2007; **18**:560–5.

34 Khaldi F, Fakhfakh R, Mattoussi N, Ben Ali B, Zouari S, Khémiri M. Prevalence and severity of asthma, allergic rhinoconjunctivitis and atopic eczema in "Grand Tunis" schoolchildren: ISAAC. *Tunis Med* 2005; **83**:269–73.

35 Kambarami RA, Marechera F, Sibanda EN, Chitiyo ME. Aero-allergen sensitisation patterns amongst atopic Zimbabwean children. *Cent Afr J Med* 1999; **45**:144–7.

36 Aït-Khaled A, Pearce N, Anderson HR *et al.*; ISAAC Phase Three Study Group. Global map of the prevalence of symptoms of rhinoconjunctivitis in children: the International Study of Asthma and Allergies in Childhood (ISAAC) phase three. *Allergy* 2009; **64**:123–48.

37 Kong WJ, Chen JJ, Zheng ZY, Shi QM, Zhou Y. Prevalence of allergic rhinitis in 3-6-year-old children in Wuhan of China. *Clin Exp Allergy* 2009; **39**:869–74.
38 Leung R, Jenkins M. Asthma, allergy and atopy in southern Chinese school students. *Clin Exp Allergy* 1994; **24**:353–8.
39 Leung R, Ho P. Asthma, allergy, and atopy in three south-east Asian populations. *Thorax* 1994; **49**:1205–10.
40 Zhao T, Wang HJ, Chen Y *et al.* Prevalence of childhood asthma, allergic rhinitis and eczema in Urumqi and Beijing. *J Paediatr Child Health* 2000; **36**:128–33.
41 Zhang L, Han D, Huang D *et al.* Prevalence of self-reported allergic rhinitis in eleven major cities in China. *Int Arch Allergy Immunol* 2009; **149**: 47–57.
42 Lau YL, Karlberg J. Prevalence and risk factors of childhood asthma, rhinitis and eczema in Hong Kong. *J Paediatr Child Health* 1998; **34**:47–52.
43 Lee SL, Wong W, Lau YL. Increasing prevalence of allergic rhinitis but not asthma among children in Hong Kong from 1995 to 2001 (Phase 3 International Study of Asthma and Allergies in Childhood. *Pediatr Allergy Immunol* 2004; **15**:72–8.
44 Kuroiwa C, Odajima H, Oudavong B *et al.* Prevalence of asthma, rhinitis, and eczema among children in Vientiane city, Lao PDR. *Southeast Asian J Trop Med Public Health* 2006; **37**:1025–33.
45 Saitoh Y, Dake Y, Shimazu S *et al.* Month of birth, atopic disease, and atopic sensitization. *J Investig Allergol Clin Immunol* 2001; **11**:183–7.
46 Sakurai Y, Nakamura K, Teruya K *et al.* Prevalence and risk factors of allergic rhinitis and cedar pollinosis among Japanese men. *Prev Med* 1998; **27**:617–22.
47 Kim SH, Kim YK, Lee MH *et al.* Relationship between sensitization to citrus red mite (*Panonychus citri*) and the prevalence of atopic diseases in adolescents living near citrus orchards. *Clin Exp Allergy* 2002; **32**:1054–8.
48 Lee MH, Kim YK, Min KU *et al.* Differences in sensitization rates to outdoor aeroallergens, especially citrus red mite (*Panonychus citri*), between urban and rural children. *Ann Allergy Asthma Immunol* 2001; **86**:691–5.
49 Kim TB, Kim YK, Chang YS *et al.* Association between sensitization to outdoor spider mites and clinical manifestations of asthma and rhinitis in the general population of adults. *J Korean Med Sci* 2006; **21**:247–52.
50 Kim YK, Son JW, Kim HY *et al.* Citrus red mite (*Panonychus citri*) is the most common sensitizing allergen of asthma and rhinitis in citrus farmers. *Clin Exp Allergy* 1999; **29**:1102–9.
51 Wang XS, Tan TN, Shek LP *et al.* The prevalence of asthma and allergies in Singapore; data from two ISAAC surveys seven years apart. *Arch Dis Child* 2004; **89**:423–6.
52 Ng TP, Tan WC. Epidemiology of chronic (perennial) rhinitis in Singapore: prevalence estimates, demographic variation and clinical allergic presentation. *Ann Acad Med Singapore* 1994; **23**:83–8.
53 Liao PF, Sun HL, Lu KH, Lue KH. Prevalence of childhood allergic diseases in central Taiwan over the past 15 years. *Pediatr Neonatol* 2009; **50**:18–25.
54 Chiang LC, Chen YH, Hsueh KC, Huang JL. Prevalence and severity of symptoms of asthma, allergic rhinitis, and eczema in 10- to 15-year-old schoolchildren in central Taiwan. *Asian Pac J Allergy Immunol* 2007; **25**:1–5.
55 Kao CC, Huang JL, Ou LS, See LC. The prevalence, severity and seasonal variations of asthma, rhinitis and eczema in Taiwanese schoolchildren. *Pediatr Allergy Immunol* 2005; **16**:408–15.
56 Chen CF, Wu KG, Hsu MC, Tang RB. Prevalence and relationship between allergic diseases and infectious diseases. *J Microbiol Immunol Infect* 2001; **34**:57–62.
57 Yu JH, Lue KH, Lu KH, Sun HL, Lin YH, Chou MC. The relationship of air pollution to the prevalence of allergic diseases in Taichung and Chu-Shan in 2002. *J Microbiol Immunol Infect* 2005; **38**:123–6.
58 Lee YL, Shaw CK, Su HJ *et al.* Climate, traffic-related air pollutants and allergic rhinitis prevalence in middle-school children in Taiwan. *Eur Respir J* 2003; **21**:964–70.
59 Bunnag C, Jareoncharsri P, Tantilipikorn P, Vichyanond P, Pawankar R. Epidemiology and current status of allergic rhinitis and asthma in Thailand - ARIA Asia-Pacific Workshop report. *Asian Pac J Allergy Immunol* 2009; **27**:79–86.
60 Tai A, Volkmer R, Burton A. Prevalence of asthma symptoms and atopic disorders in preschool children and the trend over a decade. *J Asthma* 2009; **46**:343–6.
61 Robertson CF, Roberts MF, Kappers JH. Asthma prevalence in Melbourne schoolchildren: have we reached the peak? *Med J Aust* 2004; **180**:273–6.
62 Robertson CF, Dalton MF, Peat JK *et al.* Asthma and other atopic diseases in Australian children. Australian arm of the International Study of Asthma and Allergy in Childhood. *Med J Aust* 1998; **168**:434–8.
63 Downs SH, Marks GB, Belosouva EG, Peat JK. Asthma and hayfever in Aboriginal and non-Aboriginal children living in non-remote rural towns. *Med J Aust* 2001; **175**:10–3.
64 Hopper JL, Jenkins MA, Carlin JB, Giles GG. Increase in the self-reported prevalence of asthma and hay fever in adults over the last generation: a matched parent-offspring study. *Aust J Public Health* 1995; **19**:120–4.
65 Björkstén B, Dumitrascu D, Foucard T *et al.* Prevalence of childhood asthma, rhinitis and eczema in Scandinavia and Eastern Europe. *Eur Respir J* 1998; **12**:432–7.
66 Hugg T, Ruotsalainen R, Jaakkola MS, Pushkarev V, Jaakkola JJ. Comparison of allergic diseases, symptoms and respiratory infections between Finnish and Russian school children. *Eur J Epidemiol* 2008; **23**:123–33.
67 Dotterud LK, Odland JO, Falk ES. Atopic diseases among schoolchildren in Nikel, Russia, an Arctic area with heavy air pollution. *Acta Derm Venereol* 2001; **81**:198–201.
68 Dotterud LK, Odland JO, Falk ES. Atopic diseases among adults in the two geographically related arctic areas Nikel, Russia and Sør-Varanger, Norway: possible effects of indoor and outdoor air pollution. *J Eur Acad Dermatol Venereol* 2000; **14**:107–11.
69 Solé D, Mallol J, Camelo-Nunes IC, Wandalsen GF; Latin American ISAAC Study Group. Prevalence of rhinitis-related symptoms in Latin American children - results of the International Study of Asthma and

Allergies in Childhood (ISAAC) phase three. *Pediatr Allergy Immunol* 2010; **21**:e127–36.
70 Solé D, Camelo-Nunes IC, Wandalsen GF, Rosário FN, Naspitz CK; Brazilian ISAAC's Group. Prevalence of rhinitis among Brazilian schoolchildren: ISAAC phase 3 results. *Rhinology* 2007; **45**:122–8.
71 Lima RG, Pastorino AC, Casagrande RR, Sole D, Leone C, Jacob CM. Prevalence of asthma, rhinitis and eczema in 6 - 7 years old students from the western districts of São Paulo City, using the standardized questionnaire of the "International Study of Asthma and Allergies in Childhood" (ISAAC)-phase IIIB. *Clinics (Sao Paulo)* 2007; **62**:225–34.
72 Borges WG, Burns DA, Felizola ML, Oliveira BA, Hamu CS, Freitas VC. Prevalence of allergic rhinitis among adolescents from Distrito Federal, Brazil: comparison between ISAAC phases I and III. *J Pediatr (Rio J)* 2006; **82**:137–43.
73 Riedi CA, Rosário NA, Ribas LF *et al.* Increase in prevalence of rhinoconjunctivitis but not asthma and atopic eczema in teenagers. *J Investig Allergol Clin Immunol* 2005; **15**:183–8.
74 Solé D, Camelo-Nunes IC, Vana AT *et al.* Prevalence of rhinitis and related-symptoms in schoolchildren from different cities in Brazil. *Allergol Immunopathol* 2004; **32**:7–12.
75 Barraza-Villarreal A, Hernandez-Cadena L, Moreno-Macias H, Ramirez-Aguilar M, Romieu I. Trends in the prevalence of asthma and other allergic diseases in schoolchildren from Cuernavaca, Mexico. *Allergy Asthma Proc* 2007; **28**:368–74.
76 Barraza Villarreal A, Sanín Aguirre LH, Téllez Rojo MM, Lacasaña Navarro M, Romieu I. Risk factors for asthma in school children from Ciudad Juarez, Chihuahua. *J Asthma* 2003; **40**:413–23.
77 Rad MH, Hamzezadeh A. Allergic disease in 6-7-year-old schoolchildren in Urmia, Islamic Republic of Iran. *East Mediterr Health J* 2008; **14**:1044–53.
78 Miri S, Farid R, Akbari H, Amin R. Prevalence of allergic rhinitis and nasal smear eosinophilia in 11- to 15 yr-old children in Shiraz. *Pediatr Allergy Immunol* 2006; **17**:519–23.
79 Kivity S, Sade K, Abu-Arisha F, Lerman Y, Kivity S. Epidemiology of bronchial asthma and chronic rhinitis in schoolchildren of different ethnic origins from two neighbouring towns in Israel. *Pediatr Pulmonol* 2001; **32**:217–21.
80 Owayed A, Behbehani N, Al-Momen J. Changing prevalence of asthma and allergic diseases among Kuwaiti children. An ISAAC Study (Phase III). *Med Princ Pract* 2008; **17**:284–9.
81 Behbehani NA, Abal A, Syabbalo NC, Abd Azeem A, Shareef E, Al-Momen J. Prevalence of asthma, allergic rhinitis, and eczema in 13- to 14-year-old children in Kuwait: an ISAAC study. International Study of Asthma and Allergies in Childhood. *Ann Allergy Asthma Immunol* 2000; **85**: 58–63.
82 Musharrafieh U, Al-Sahab B, Zaitoun F, El-Hajj MA, Ramadan F, Tamim H. Prevalence of asthma, allergic rhinitis and eczema among Lebanese adolescents. *J Asthma* 2009; **46**:382–7.
83 Waked M, Salameh P. Asthma, allergic rhinitis and eczema in 5-12-year-old school children across Lebanon. *Public Health* 2008; **122**:965–73.
84 Ramadan FM, Khoury MN, Hajjar TA, Mroueh SM. Prevalence of allergic diseases in children in Beirut: comparison to worldwide data. *J Med Liban* 1999; **47**:216–21.
85 Al-Riyami BM, Al-Rawas OA, Al-Riyami AA, Jasim LG, Mohammed AJ. A relatively high prevalence and severity of asthma, allergic rhinitis and atopic eczema in schoolchildren in the Sultanate of Oman. *Respirology* 2003; **8**:69–76.
86 Janahi IA, Bener A, Bush A. Prevalence of asthma among Qatari schoolchildren: International Study of Asthma and Allergies in Childhood, Qatar. *Pediatr Pulmonol* 2006; **41**:80–6.
87 Sobki SH, Zakzouk SM. Point prevalence of allergic rhinitis among Saudi children. *Rhinology* 2004; **42**:137–40.
88 Al Frayh AR, Shakoor Z, Gad El Rab MO, Hasnain SM. Increased prevalence of asthma in Saudi Arabia. *Ann Allergy Asthma Immunol* 2001; **86**:292–6.
89 Alsowaidi S, Abdulle A, Shehab A, Zuberbier T, Bernsen R. Allergic rhinitis: prevalence and possible risk factors in a Gulf Arab population. *Allergy* 2010; **65**:208–12.
90 al-Maskari F, Bener A, al-Kaabi A, al-Suwaidi N, Norman N, Brebner J. Asthma and respiratory symptoms among school children in United Arab Emirates. *Allergy Immunol (Paris)* 2000; **32**:159–63.
91 Bener A, Abdulrazzaq YM, Debuse P, al-Mutawwa J. Prevalence of asthma among Emirates school children. *Eur J Epidemiol* 1994; **10**:271–8.
92 Talay F, Kurt B, Tug T, Yilmaz F, Goksugur N. Prevalence and risk factors of asthma and allergic diseases among schoolchildren in Bolu, Turkey. *Acta Paediatr* 2008; **97**:459–62.
93 Yuksel H, Dinc G, Sakar A *et al.* Prevalence and comorbidity of allergic eczema, rhinitis, and asthma in a city in western Turkey. *J Investig Allergol Clin Immunol* 2008; **18**:31–5.
94 Bahceciler NN, Ozdemir C, Kucukosmanoglu E *et al.* Association between previous enterobiasis and current wheezing: evaluation of 1018 children. *Allergy Asthma Proc* 2007; **28**:174–82.
95 Tamay Z, Akcay A, Ones U, Guler N, Kilic G, Zencir M. Prevalence and risk factors for allergic rhinitis in primary school children. *Int J Pediatr Otorhinolaryngol* 2007; **71**:463–71.
96 Akçakaya N, Kulak K, Hassanzadeh A, Camcioğlu Y, Cokuğraş H. Prevalence of bronchial asthma and allergic rhinitis in Istanbul school children. *Eur J Epidemiol* 2000; **16**:693–9.
97 Karaman O, Turgut CS, Uzuner N *et al.* The determination of asthma, rhinitis, eczema, and atopy prevalence in 9- to 11-year-old children in the city of Izmir. *Allergy Asthma Proc* 2006; **27**:319–24.
98 Zeyrek CD, Zeyrek F, Sevinc E, Demir E. Prevalence of asthma and allergic diseases in Sanliurfa, Turkey, and the relation to environmental and socioeconomic factors: is the hygiene hypothesis enough? *J Investig Allergol Clin Immunol* 2006; **16**:290–5.
99 Tomac N, Demirel F, Acun C, Ayoglu F. Prevalence and risk factors for childhood asthma in Zonguldak, Turkey. *Allergy Asthma Proc* 2005; **26**:397–402.
100 Bayram I, Güneşer-Kendirli S, Yilmaz M, Altintaş DU, Alparslan N, Bingöl-Karakoç G. The prevalence of asthma and allergic diseases in children of school age in Adana in southern

Turkey. *Turk J Pediatr* 2004; **46**: 221–5.
101 Ece A, Ceylan A, Saraçlar Y, Saka G, Gürkan F, Haspolat K. Prevalence of asthma and other allergic disorders among schoolchildren in Diyarbakir, Turkey. *Turk J Pediatr* 2001; **43**:286–92.
102 Kuyucu S, Saraçlar Y, Tuncer A *et al.* Epidemiologic characteristics of rhinitis in Turkish children: the International Study of Asthma and Allergies in Childhood (ISAAC) phase 2. *Pediatr Allergy Immunol* 2006; **17**:269–77.
103 Selçuk ZT, Caglar T, Enünlü T, Topal T. The prevalence of allergic diseases in primary school children in Edirne, Turkey. *Clin Exp Allergy* 1997; **27**:262–9.
104 Unlü M, Orman A, Dogan N. The prevalence of asthma among secondary school students in Afyon, Turkey. *Asian Pac J Allergy Immunol* 2002; **20**:1–6.
105 Ozdemir N, Uçgun I, Metintas S, Kolsuz M, Metintas M. The prevalence of asthma and allergy among university freshmen in Eskisehir, Turkey. *Respir Med* 2000; **94**:536–41.
106 Sakar A, Yorgancioglu A, Dinc G *et al.* The prevalence of asthma and allergic symptoms in Manisa, Turkey (A western city from a country bridging Asia and Europe). *Asian Pac J Allergy Immunol* 2006; **24**:17–25.
107 Dinmezel S, Ogus C, Erengin H, Cilli A, Ozbudak O, Ozdemir T. The prevalence of asthma, allergic rhinitis, and atopy in Antalya, Turkey. *Allergy Asthma Proc* 2005; **26**:403–9.
108 Başak O, Başak S, Gültekin B, Tekin N, Söylemez A. The prevalence of allergic rhinitis in adults in Aydin, Turkey. *Rhinology* 2006; **44**:283–7.
109 Cingi C, Topuz B, Songu M *et al.* Prevalence of allergic rhinitis among the adult population in Turkey. *Acta Otolaryngol* 2010; **130**:600–6.
110 Potter PC, Crombie I, Marian A, Kosheva O, Maqula B, Schinkel M. Latex allergy at Groote Schuur Hospital–prevalence, clinical features and outcome. *S Afr Med J* 2001; **91**:760–5.
111 Ngom AS, Koffi N, Blessey M, Aka-Danguy E. Prevalence of allergy to cockroaches in the African intertropical zone. *Allerg Immunol (Paris)* 1999; **31**:351–6.
112 Li J, Sun B, Huang Y *et al.* China Alliance of Research on Respiratory Allergic Disease. A multicentre study assessing the prevalence of sensitizations in patients with asthma and/or rhinitis in China. *Allergy* 2009; **64**:1083–92.
113 Liu GH, Zhu RF, Zhang W, Li WJ, Wang ZX, Chen H. Survey of airborne pollen in Hubei province of China. *Chin Med Sci J* 2008; **23**:212–7.
114 Celedón JC, Palmer LJ, Weiss ST, Wang B, Fang Z, Xu X. Asthma, rhinitis, and skin test reactivity to aeroallergens in families of asthmatic subjects in Anqing, China. *Am J Respir Crit Care Med* 2001; **163**: 1108–12.
115 Kaufman HS, Kelly PT, Modin GW. Antigen recognition in Chinese and Caucasians. *Ann Allergy* 1984; **53**:135–7.
116 Kaufman HS, Ranck K. Antigen recognition in Filipinos, Japanese, Chinese, and Caucasians. *Ann Allergy* 1988; **60**:53–6.
117 Takasaki K, Enatsu K, Kumagami H, Takahashi H. Relationship between airborne pollen count and treatment outcome in Japanese cedar pollinosis patients. *Eur Arch Otorhinolaryngol* 2009; **266**:673–6.
118 Ozasa K, Hama T, Dejima K *et al.* A 13-year study of Japanese cedar pollinosis in Japanese schoolchildren. *Allergol Int* 2008; **57**:175–80.
119 Ozasa K, Dejima K, Takenaka H. Prevalence of Japanese cedar pollinosis among schoolchildren in Japan. *Int Arch Allergy Immunol* 2002; **128**: 165–77.
120 Ozasa K, Dejima K, Hama T, Watanabe Y, Takenaka H. Exposure to Japanese cedar pollen in early life and subsequent sensitization to Japanese cedar pollen. *J Epidemiol* 2000; **10**:42–7.
121 Ito H, Baba S, Mitani K. Connection between NO(x) and SO(x) collected from the Japanese cedar tree and pollinosis. *Acta Otolaryngol Suppl* 1996; **525**:79–84.
122 Kurosaka F, Nakatani Y, Terada T *et al.* Current cat ownership may be associated with the lower prevalence of atopic dermatitis, allergic rhinitis, and Japanese cedar pollinosis in schoolchildren in Himeji, Japan. *Pediatr Allergy Immunol* 2006; **17**:22–8.
123 Nakamaru Y, Maguchi S, Oridate N, Takagi D, Furuta Y, Fukuda S. *Plantago lanceolata* (English plantain) pollinosis in Japan. *Auris Nasus Larynx* 2005; **32**:251–6.
124 Yamagiwa M, Hattori R, Ito Y *et al.* Birch-pollen sensitization in an area without atmospheric birch pollens. *Auris Nasus Larynx* 2002; **29**:261–6.
125 Miyahara S, Nakada M, Nishizaki K, Kawarai Y, Nishioka K, Hino H. Cross-reactivity to olive tree pollen and orchard grass pollen in patients with pollinosis. *Acta Med Okayama* 1997; **51**:167–71.
126 Suzuki M, Itoh H, Sugiyama K *et al.* Causative allergens of allergic rhinitis in Japan with special reference to silkworm moth allergen. *Allergy* 1995; **50**:23–7.
127 Lee MH, Cho SH, Park HS *et al.* Citrus red mite (*Panonychus citri*) is a common sensitizing allergen among children living around citrus orchards. *Ann Allergy Asthma Immunol* 2000; **85**:200–4.
128 Sener O, Kim YK, Ceylan S, Ozanguc N, Yoo TJ. Comparison of skin tests to aeroallergens in Ankara and Seoul. *J Investig Allergol Clin Immunol* 2003; **13**:202–8.
129 Hsu SP, Lin KN, Tan CT, Lee FP, Huang HM. Prenatal risk factors and occurrence of allergic rhinitis among elementary school children in an urban city. *Int J Pediatr Otorhinolaryngol* 2009; **73**:807–10.
130 Hwang BF, Jaakkola JJ, Lee YL, Lin YC, Guo YL. Relation between air pollution and allergic rhinitis in Taiwanese schoolchildren. *Respir Res* 2006; **7**:23.
131 Li LF, Lin MC, Yang CT *et al.* Comparison of indoor allergens, allergic scores, and demographic data in Taiwanese adults with asthma or allergic rhinitis, or both. *J Formos Med Assoc* 1999; **98**:486–91.
132 Chen WY, Tseng HI, Wu MT *et al.* Synergistic effect of multiple indoor allergen sources on atopic symptoms in primary school children. *Environ Res* 2003; **93**:1–8.
133 Tang RB, Tsai LC, Hwang HM, Hwang B, Wu KG, Hung MW. The prevalence of allergic disease and IgE antibodies to house dust mite in schoolchildren in Taiwan. *Clin Exp Allergy* 1990; **20**:33–8.
134 Johnston FH, Hanigan IC, Bowman DM. Pollen loads and allergic rhinitis in Darwin, Australia: a potential health outcome of the grass-fire cycle. *EcoHealth* 2009; **6**:99–108.
135 Kemp A, Ponsonby AL, Dwyer T *et al.* The interaction between early life

upper respiratory tract infection and birth during the pollen season on rye-sensitized hay fever and ryegrass sensitization - a birth cohort study. *Pediatr Allergy Immunol* 2009; **20**:536–44.
136 Andreasyan K, Ponsonby AL, Dwyer T *et al.* A differing pattern of association between dietary fish and allergen-specific subgroups of atopy. *Allergy* 2005; **60**:671–7.
137 Andersson M, Downs S, Mitakakis T, Leuppi J, Marks G. Natural exposure to Alternaria spores induces allergic rhinitis symptoms in sensitized children. *Pediatr Allergy Immunol* 2003; **14**:100–5.
138 Bass DJ, Delpech V, Beard J, Bass P, Walls RS. Late summer and fall (March-May) pollen allergy and respiratory disease in Northern New South Wales, Australia. *Ann Allergy Asthma Immunol* 2000; **85**:374–81.
139 Leung RC, Carlin JB, Burdon JG, Czarny D. Asthma, allergy and atopy in Asian immigrants in Melbourne. *Med J Aust* 1994; **161**:418–25.
140 Hurry VM, Peat JK, Woolcock AJ. Prevalence of respiratory symptoms, bronchial hyper-responsiveness and atopy in schoolchildren living in the Villawood area of Sydney. *Aust N Z J Med* 1988; **18**:745–52.
141 Codina R, Ardusso L, Lockey RF, Crisci C, Bertoya N. Sensitization to soy bean hull allergens in subjects exposed to different levels of soybean dust inhalation in Argentina. *J Allergy Clin Immunol* 2000; **105**:570–6.
142 Alonso A, Irañeta SG, Rodríguez SM, Scavini LM, Rodríguez SR. Bat faeces as an indoor allergen. *J Investig Allergol Clin Immunol* 1998; **8**:365–9.
143 Bernardes CT, Moreira PF, Sopelete MC *et al.* IgE cross-reactivity between *Lolium multiflorum* and commercial grass pollen allergen extracts in Brazilian patients with pollinosis. *Braz J Med Biol Res* 2010; **43**:166–75.
144 Sopelete MC, Moreira PF, Silva DA *et al.* Sensitization to *Lolium multiflorum* grass pollen in pollinosis patients: evaluation of allergenic fractions recognized by specific IgE antibodies. *Int Arch Allergy Immunol* 2006; **140**:121–30.
145 Rona RJ, Vargas C, Vianna EO *et al.* Impact of specific sensitization on asthma and rhinitis in young Brazilian and Chilean adults. *Clin Exp Allergy* 2008; **38**:1778–86.
146 Pastorino AC, Kuschnir FC, Arruda LK *et al.* Sensitisation to aeroallergens in Brazilian adolescents living at the periphery of large subtropical urban centres. *Allergol Immunopathol (Madr)* 2008; **36**:9–16.
147 Bernd LA, Ambrozio LC, Baggio D. Storage mite allergy in perennial rhinitis patients not sensitized to house dust mites. *J Investig Allergol Clin Immunol* 1996; **6**:94–7.
148 Santos AB, Chapman MD, Aalberse RC *et al.* Cockroach allergens and asthma in Brazil: identification of tropomyosin as a major allergen with potential cross-reactivity with mite and shrimp allergens. *J Allergy Clin Immunol* 1999; **104**:329–37.
149 Soto-Quiros ME, Silverman EK, Hanson LA, Weiss ST, Celedón JC. Maternal history, sensitization to allergens, and current wheezing, rhinitis, and eczema among children in Costa. *Rica Pediatr Pulmonol* 2002; **33**:237–43.
150 Rocha-Estrada A, Alvarado-Vázquez MA, Torres-Cepeda TE, Foroughbakhch-Pournavab R, Hernández-Piñero JL. Airborne pollen of Carya, Celtis, Cupressus, Fraxinus and Pinus in the metropolitan area of Monterrey Nuevo Leon, Mexico. *Ann Agric Environ Med* 2008; **15**:205–9.
151 Puccio FA, Lynch NR, Noya O *et al.* Importance of including *Blomia tropicalis* in the routine diagnosis of Venezuelan patients with persistent allergic symptoms. *Allergy* 2004; **59**:753–7.
152 Galante D, Hartung de Capriles C, Mata-Essayag S *et al.* Respiratory allergies in Venezuela: are fungi responsible? *Mycoses* 2006; **49**:493–8.
153 Waibel KH. Allergic rhinitis in the Middle East. *Mil Med* 2005; **170**:1026–8.
154 Fereidouni M, Hossini RF, Azad FJ, Assarehzadegan MA, Varasteh A. Skin prick test reactivity to common aeroallergens among allergic rhinitis patients in Iran. *Allergol Immunopathol (Madr)* 2009; **37**:73–9.
155 Geller-Bernstein C, Zaharan Y, Waisel Y. Sensitivity to *Olea europaea* pollen in different populations in Israel. *Allerg Immunol (Paris)* 1994; **26**:318–9.
156 Al-Dowaisan A, Fakim N, Khan MR *et al.* Salsola pollen as a predominant cause of respiratory allergies in Kuwait. *Ann Allergy Asthma Immunol* 2004; **92**:262–7.
157 Behbehani N, Arifhodzic N, Al-Mousawi M *et al.* The seasonal variation in allergic rhinitis and its correlation with outdoor allergens in Kuwait. *Int Arch Allergy Immunol* 2004; **133**:164–7.
158 Sattar HA, Mobayed H, Al-Mohammed AA *et al.* The pattern of indoor and outdoor respiratory allergens in asthmatic adult patients in a humid and desert newly developed country. *Eur Ann Allergy Clin Immunol* 2003; **35**:300–5.
159 Sorensen H, Ashoor AA, Maglad S. Perennial rhinitis in Saudi Arabia. A prospective study. *Ann Allergy* 1986; **56**:76–80.
160 Lestringant GG, Bener A, Frossard PM, Abdulkhalik S, Bouix G. A clinical study of airborne allergens in the United Arab Emirates. *Allerg Immunol (Paris)* 1999; **31**:263–7.
161 Can IH, Islam A, Karasoy DS, Samim EE. Does regional pollen load affect the prevalence of clinical allergy to those pollen groups? *J Laryngol Otol* 2010; **124**:297–301.
162 Aydin S, Hardal U, Atli H. An analysis of skin prick test reactions in allergic rhinitis patients in Istanbul, Turkey. *Asian Pac J Allergy Immunol* 2009; **27**:19–25.
163 Berna Dursun A, Celik GE, Alan S, Münevver Pinar N, Mungan D, Misirligil Z. Regional pollen load: effect on sensitisation and clinical presentation of seasonal allergic rhinitis in patients living in Ankara, Turkey. *Allergol Immunopathol (Madr)* 2008; **36**:371–8.
164 Erkara IP, Cingi C, Ayranci U, Gurbuz KM, Pehlivan S, Tokur S. Skin prick test reactivity in allergic rhinitis patients to airborne pollens. *Environ Monit Assess* 2009; **151**:401–12.
165 Türe C, Böcük H. Analysis of airborne pollen grains in Bilecik, Turkey. *Environ Monit Assess* 2009; **151**:27–35.
166 Mösges R, Klimek L. Today's allergic rhinitis patients are different: new factors that may play a role. *Allergy* 2007; **62**:969–75.
167 Simoni M, Lombardi E, Berti G *et al.* Effects of indoor exposures on respiratory and allergic disorders. *Epidemiol Prev* 2005; **29**:57–61.

168 Jaakkola JJ, Hwang BF, Jaakkola N. Home dampness and molds, parental atopy, and asthma in childhood: a six-year population-based cohort study. *Environ Health Perspect* 2005; **113**:357–61.
169 Jacob B, Ritz B, Gehring U *et al.* Indoor exposure to molds and allergic sensitization. *Environ Health Perspect* 2002; **110**:647–53.
170 Yang CY, Chiu JF, Cheng MF, Lin MC. Effects of indoor environmental factors on respiratory health of children in a subtropical climate. *Environ Res* 1997; **75**:49–55.
171 Zuraimi MS, Tham KW, Chew FT, Ooi PL, Koh D. Home air-conditioning, traffic exposure, and asthma and allergic symptoms among preschool children. *Pediatr Allergy Immunol* 2011; **22**:e112–8.
172 Gehring U, Wijga AH, Brauer M *et al.* Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. *Am J Respir Crit Care Med* 2010; **181**:596–603.
173 Wong TW, Yu TS, Liu HJ, Wong AH. Household gas cooking: a risk factor for respiratory illnesses in preschool children. *Arch Dis Child* 2004; **89**:631–6.
174 Bunyavanich S, Soto-Quiros ME, Avila L, Laskey D, Senter JM, Celedón JC. Risk factors for allergic rhinitis in Costa Rican children with asthma. *Allergy* 2010; **65**:256–63.
175 Bousquet J, Vignola AM, Demoly P. Links between rhinitis and asthma. *Allergy* 2003; **58**:691–706.
176 Braunstahl GJ, Fokkens W. Nasal involvement in allergic asthma. *Allergy* 2003; **58**:1235–43.
177 Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention 2009 (update). Available at www.ginasthma.org (accessed 5 October 2010).
178 Schatz M, Meltzer EO, Nathan R *et al.* Psychometric validation of the rhinitis control assessment test: a brief patient-completed instrument for evaluating rhinitis symptom control. *Ann Allergy Asthma Immunol* 2010; **104**:118–24.