

Chapter 2

Allergic Diseases in the Developing World: An Emerging Problem or an Overseen Issue?



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Allergic diseases are defined as a hypersensitivity or overreaction of the immune system to seemingly harmless substances in the environment. While being impacted by the environment, they are also closely linked to the genetic background of the individuals affected. A number of allergic conditions can be observed as a result of this altered immune response, such as atopic dermatitis, asthma, allergic rhinitis, and food sensitivity/allergy. Although allergens are different throughout the world and in different environments, some are more commonly known to cause an allergic response in many populations; these include pollens, dust mites, animal dander, insect bites, and certain foods such as nuts and seafood.

Historically, allergic diseases were seen more commonly in industrialized populations and more so in urban areas compared to rural regions. However, in the past few decades, a changing trend has been witnessed, and higher incidence of allergic diseases is observed in developing countries as well. This rise has been attributed to the effects of modernization, industrialization, and improved sanitation in those countries, as well as greater access to various foods. Modern life changes such as overcleaning, access to filtered and sanitized water, use of pesticides, detergents and cleaners, as well as food storage and transportation have decreased exposure to many antigens that individuals would previously be in contact with on a daily basis. But how does this affect allergic diseases? The answer is described by the “hygiene hypothesis,” which is, perhaps, the most credible explanation for the observed change caused by modernization [1, 2]. The hygiene hypothesis states that decreased exposure to bacteria early on in life inhibits full immune system development, making individuals prone to allergic diseases [1]. Therefore, the more sterile the living environment in early life, the higher the incidence of allergic diseases. The hygiene hypothesis is supported by migration studies where individuals from developing countries with low incidence of allergic and autoimmune diseases who migrated to

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developed countries with high incidence of these diseases acquired these conditions at rates similar to that of natives of the developed country, emphasizing the role of modern lifestyles and the environment in the development of these conditions [3]. With that said, two important factors influencing this observation are the length of stay of migrants and their age at the time of migration. This reinforces the idea that the lack of exposure to bacteria in *early childhood* is what leads to the exacerbated immune response.

Some of the consequences of this altered immune function have a greater impact on individuals' lives than others. Asthma, for example, characterized by inflammation and narrowing of the airways, affected 339 million people worldwide in 2018. Although its exact cause is not known, there is strong evidence linking atopy and asthma to the hygiene hypothesis [4]. However, most observations of asthma as an allergic disease come predominantly from high-income, developed countries, and the association of the two is weaker in low- and middle-income or developing countries. Could this be a truly weak association though? Or is it simply because data are lacking from developing countries?

Although it is speculated that the prevalence of allergic diseases in developing countries is growing, data is lacking on the exact rates of these conditions in various parts of the world. What is certain, however, is that prevalence rates are still lower than those observed in developed countries. With that said, because of poorer economic conditions and lack of access to appropriate medical care, the health and economic impact of these diseases appear to be higher in developing and underprivileged countries [5].

In the following sections, we will first review the available data on the prevalence of allergic diseases in developing countries and discuss trends and patterns seen over the past few decades, and then, we will discuss the overall risk factors and common allergens, followed by the burden caused by allergic diseases in these countries.

Prevalence of Allergic Diseases: An Overview

The International Study of Asthma and Allergies in Childhood (ISAAC) is the largest worldwide collaborative epidemiological research project investigating asthma, rhinitis, and eczema, including data from over 100 countries. The study started in 1991 and has had several phases carried out thus far. Early data from the study reported an astounding 20-fold to 60-fold difference in asthma, allergic rhinoconjunctivitis, and atopic dermatitis (eczema) among children in different parts of the world [6]. As expected, these diseases were highest in developed countries, such as the United Kingdom, Australia, New Zealand, and Ireland, and lowest in developing countries, such as Indonesia, China, Taiwan, Uzbekistan, India, and Ethiopia [7]. But prevalence rates increased throughout the world from Phase I to Phase III studies, with 6- to 7-year-old children of Jodhpur, India, experiencing the lowest rates (2.4%) and those in Costa Rica experiencing the highest (37.6%).

Asthma trends: The rates of asthma are markedly varied across the globe. Adolescents (13–14 years of age) in Tibet and New Zealand experienced the lowest and highest rates of asthma, respectively (0.8% vs. 32.6%) [5]. The countries experiencing the highest rates of asthma most often had higher rates of allergic rhinoconjunctivitis as well.

Atopic dermatitis followed different patterns, with African countries being among those with higher prevalence rates. Studies on atopic dermatitis revealed rates as low as <2% in Iran to over 16% in Japan and Sweden in 6–7 year olds. The rates were also varied in older children in different parts of the world with rates of <1% in Albania and over 17% in Nigeria in 13- to 14-year-old children [7]. Phase III data from ISAAC in 2008 showed the increasing trend in atopic dermatitis with the highest rates being in Asia and Latin America. In children 13–14 years of age, atopic dermatitis ranged from 0.2% in China to 24.6% in Columbia with the highest rates again in Africa and Latin America [8].

Food allergies are another major category of allergic diseases, and although there is a lack of high-quality studies using gold standard techniques of diagnosing food allergies, the available data still shows an increasing trend in developed and developing countries, with some developing countries showing rates as high as developed countries [9, 10]. Genome–environment interactions are evidenced by studies investigating food allergies in migrants or descendants of low- and middle-income countries growing up in developed countries. These studies have shown that the rates of food allergies in these immigrant populations are even higher than that observed in natives of those developed countries [10].

One very important factor when comparing prevalence rates among different countries is having the same diagnostic criteria for a disease, as different criteria in the same population can give varying results, let alone in different populations around the world. And while not all studies published in the past few decades use the same diagnostic criteria, many are either part of the ISAAC project or have adopted its protocols and questionnaires, performing the same study in 6-to 7-year-old and 13- to 14-year-old children, making their results ideal for comparison. Although all relevant studies have been included in the sections presented in this chapter, for the sake of convenience, studies using ISAAC guidelines are marked in the tables associated with each section.

Prevalence and Trends of Allergic Diseases: Africa

The prevalence of allergic diseases varies widely between African countries and even within different regions of one country. Data from selected countries are presented in Table 2.1. The lowest rates of asthma are reported in children from a low socioeconomic region of Nigeria (0.9%), while highest rates are observed in South Africa and Congo (20.3% and 19.9%, respectively) [11, 12]. Allergic rhinitis rates as high as 38.5% and 61.7% have been reported in the general population of South Africa and Benin, respectively [13, 14]. Data from African countries is very limited,

Table 2.1 African countries

Region	Countries <i>n</i> = 27	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
Africa	Algeria	Asthma: 1.2–1.34% (GP) 1.6% (<5Y) 3.4–4.1% (5–25Y)	Asthma: 3.45% (GP)			[52, 196, 197]
	Angola			Asthma: 15.8% (6–7Y) ^{ISAAC} 13.4% (13–14Y) ^{ISAAC} ^a Allergic rhinitis: 19% (6–7Y) ^{ISAAC} 27% (13–14Y) ^{ISAAC} , ^a Eczema/atopic dermatitis: 22% (6–7Y) ^{ISAAC} 20% (13–14Y) ^{ISAAC} , ^a		[60, 198]
	Benin			Allergic rhinitis 35.7% (6–65Y) Allergic rhinoconjunctivitis: 61.7% (6–65Y)	Indoor allergens: house dust, pets (dogs and cats) Outdoor allergens: air pollution	[13]
	Botswana			Asthma: 15.9% (6–7Y) ^{ISAAC} , ^a 16.3% (13–14Y) ^{ISAAC} , ^a		[59]

Burkina Faso		Asthma: 9.6% (15–64Y)			[199]
Cameroon		Current wheeze: 0.8–5.4% (5–15Y) 1.3–2.5% (>15Y)	Asthma: 2.7% (A) Current wheeze: 2.9% (A) Allergic rhinitis: 10.4% (A) 24.5% (A) Allergic rhinoconjunctivitis: 5.4% (A)	Indoor allergens: mites Food allergens: wheat	[200–202]
Congo (Democratic Republic of)		Asthma: 19.9% (GP)	Current wheeze: 15.4% (5–83Y) Allergic rhinitis: 30.8% (5–83Y) Allergic rhinoconjunctivitis: 24.4% (5–83Y)	Indoor allergens: cockroach, <i>D. pteromyssinus</i>	[107]
Egypt		Asthma: 9.4% (11–15Y) ^{ISAAC} Current wheeze: 14.7% (11–15Y) ^{ISAAC} Allergic rhinoconjunctivitis: 15.3% (11–15Y) ^{ISAAC}			[54]

(continued)

Table 2.1 (continued)

Region	Countries $n = 27$	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
Ethiopia	Asthma: 2.8% (13–14Y) ^{ISAAC} Current wheeze: 18.2% (13–14Y) ^{ISAAC}	Current wheeze: 16.2% (13–14Y) ^{ISAAC} Allergic rhinoconjunctivitis: 14.5% (13–14Y) ^{ISAAC} Eczema/atopic dermatitis: 1.2% (GP) 10.9% (13–14Y) ^{ISAAC}	Current wheeze: 11.5% (1Y) Eczema/atopic dermatitis: 8.6% (1Y)	Indoor/housing allergens: residence in brick houses, wooden walls and floors, place of sleeping (floor vs. bed/platform) Outdoor allergens: pollen	[53, 56, 203–205]	
Ghana			Allergic rhinoconjunctivitis: 39.9% (C-T) Eczema/atopic dermatitis: 1.5–1.6% (C-T) ^{ISAAC}	Indoor allergens: mite, cockroach Other allergens: inner-city residence	[58, 206]	
Guinea		Asthma: 18.6% (GP)			[11]	
Ivory coast	Asthma: 10.8% (C) Current wheeze: 19.8% (C)	Asthma: 19.3% (GP)			[207]	

Kenya	<p>Asthma: 6.6% (13-14Y)^{ISAAC}</p> <p>Current wheeze: 21.2% (13-14Y)^{ISAAC}</p> <p>Allergic rhinitis: 14.9% (13-14Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 13.9% (13-14Y)^{ISAAC}</p>	<p>Asthma: 12.6% (13-14Y)^{ISAAC}</p> <p>18.0% (GP)</p> <p>Current wheeze: 23.6% (13-14Y)^{ISAAC}</p> <p>Allergic rhinitis: 38.6% (13-14Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 28.5% (13-14Y)^{ISAAC}</p>			[15]
Madagascar			<p>Current wheeze: 25.2% (7-14Y)^{ISAAC}</p>		[208]
Mongolia		<p>Asthma: 1.1%-2.4 (10-60Y)</p> <p>Allergic rhinoconjunctivitis: 9.3-18.4% (10-60Y)</p>			[106]

(continued)

Table 2.1 (continued)

Region	Countries $n = 27$	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	Morocco		Asthma: 3.89% (GP) Current wheeze: 6.4–16.2% (13–14Y) ^{ISAAC} Allergic rhinitis: 37.8% (<10–49Y) ^{ISAAC} Allergic rhinoconjunctivitis: 8.8–28% (13–14Y) ^{ISAAC} Eczema/atopic dermatitis: 13.3–20.2% (13–14Y) ^{ISAAC}			[90, 196, 209]
	Mozambique		Asthma: 11.9% (13–14Y) ^{ISAAC}			[210]

Nigeria	<p>Asthma: 18.4% (C)^{ISAAC}</p> <p>Current wheeze: 10.7–16.4% (C)^{ISAAC}</p> <p>Allergic rhinitis: 45.2–54.1% (C)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 22.4–26.1% (C)^{ISAAC}</p>	<p>Asthma: 14.7% (18–45Y)</p> <p>Current wheeze: 4.8–5.5% (6–7Y)^{ISAAC}</p> <p>7.2% (6–7Y)^{ISAAC}</p> <p>10.7–13.0% (13–14Y)^{ISAAC}</p> <p>Allergic rhinitis: 11.3% (6–7Y)^{ISAAC}</p> <p>29.6% (18–45Y)</p> <p>Eczema/atopic dermatitis: 10.1% (6–7Y)^{ISAAC}</p>	<p>Asthma: 0.9% (7–14Y)^{ISAAC}</p> <p>Current wheeze: 5.4% (7–14)^{ISAAC}</p> <p>Allergic rhinitis: 19.2% (7–14Y)^{ISAAC}</p>	Indoor allergens: house dust mites, mold	[12, 55, 211–213]
Reunion island		<p>Asthma: 21.5% (GP)</p>			[11]
Senegal			<p>Asthma: 3% (C)^{ISAAC}</p> <p>12.8% (<15Y)^{ISAAC}</p> <p>Current wheeze: 9% (C)^{ISAAC}</p> <p>Allergic rhinoconjunctivitis: 12.5% (<15Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 12.2% (<15Y)^{ISAAC}</p>		[214, 215]

(continued)

Table 2.1 (continued)

Region	Countries $n = 27$	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	South Africa	<p>Asthma: 13.1% (13–14Y)^{ISAAC}</p> <p>Current wheeze: 16% (13–14Y)^{ISAAC}</p> <p>Allergic rhinitis: 30.4% (13–14Y)^{ISAAC}</p> <p>Allergic rhinoconjunctivitis: 17.6% (13–14Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 11.8% (13–14Y)^{ISAAC}</p>	<p>Asthma: 14.4% (13–14Y)^{ISAAC}</p> <p>Current wheeze: 18.0–20.3% (GP)</p> <p>Current wheeze: 20.3% (13–14Y)^{ISAAC}</p> <p>Allergic rhinitis: 38.5% (13–14Y)^{ISAAC}</p> <p>Allergic rhinoconjunctivitis: 24.3% (13–14Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 19.4% (13–14Y)^{ISAAC}</p>	<p>Asthma 3.4% (9–11Y)^{ISAAC, a}</p> <p>Current wheeze: 12.9% (9–11Y)^{ISAAC, a}</p> <p>Food allergy (peanuts) 15–38% (C)</p> <p>40% (C)</p>	<p>Indoor allergens: visible mold growth, dampness, paraffin use for cooking</p> <p>Food allergens: peanuts</p>	[14, 19, 216]
	Tanzania		<p>Current wheeze: 1.9–5.2% (5–15Y)</p> <p>2.2–5.0% (>15Y)</p>	<p>Asthma (self-reported): 6.4–17.6% (17Y)^{ISAAC}</p> <p>Current wheeze 12.1–23.1% (17Y)^{ISAAC}</p>		[108, 202]
	Togo			<p>Eczema/atopic dermatitis: 31.3% (0–15Y)</p>		[217]

Tunisia	<p>Asthma: 3.53% (GP)</p> <p>Current wheeze: 13.2% (13–14Y)^{ISAAC}</p> <p>Allergic rhinoconjunctivitis: 29.7% (13–14Y)^{ISAAC}</p> <p>Eczema/atopic dermatitis: 8.3% (13–14Y)^{ISAAC}</p>	<p>Asthma: 6.5% (2–52Y)^{ISAAC}</p> <p>Allergic rhinitis: 11.7% (<15Y)^{ISAAC} 13.4% (>15Y)^{ISAAC}</p>		[196, 218, 219]
Uganda		<p>Asthma: 6.8 (>35Y)</p> <p>Allergic rhinitis: 11.9% (>35Y)</p> <p>Eczema/atopic dermatitis: 8.2% (>35Y)</p>	Indoor allergens: use of gas for cooking	[109, 220]

The superscript ^{ISAAC} indicates studies that have used ISAAC protocol/questionnaires

A adults, C children, E elderly, GP general population, T teens, Y years

^aResults from multicenter studies

and it is hard to pinpoint exact high and low regions, but even with the scarce amount of data available, the increasing trend in allergic diseases over the past few decades is evident. The same survey repeated 6 years apart in Kenyan adolescents showed significant changes over time. The rate of asthma increased from 6.6% to 12.6%, while allergic rhinitis increased from 14.9% to 38.6% and atopic dermatitis increased from 13.9% to 28.5% [15]. South Africa also showed similar trends with a 1–8.5% increase in different allergic diseases over a 7-year period [14].

Food allergies also appear to be on the rise in African countries with highest rates reported in Zimbabwe (10%) and Morocco (9.5%) [16]. Self-reported food reactions are as high as 28% in Nigeria [17]. Forty percent of children with atopic dermatitis in South Africa have a peanut allergy, one of the most common allergens [18, 19]. Other foods known to cause allergic reactions in various African countries include apples, tomatoes, soy, crab, egg whites, and milk. Sea food allergy is also high in certain regions of South Africa [20].

Prevalence and Trends of Allergic Diseases: Middle East

Most data in the Middle East come from studies performed in Turkey followed by Iran and Saudi Arabia. Before talking about individual countries, however, it would be best to get an overall picture of asthma status in that region by noting the meta-analysis performed in 2018 in the Eastern Mediterranean Region countries (Afghanistan, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates (UAE), Yemen, and Cyprus). Using the World Health Organization definition of asthma, Masjedi et al. reported a pooled asthma prevalence of 9.38% (confidence interval: 9.20–9.55) [21]. While not all countries had the same amount of data to be reflected in this analysis equally, the highest prevalence rate was observed in Kuwait and the lowest in Syria. Another systematic review from the Arabian Peninsula including seven countries (Kuwait, UAE, Bahrain, Qatar, Oman, Kingdom of Saudi Arabia, and Yemen) reported a prevalence range of 8–23%, while the SNAPSHOT program reported lower prevalence rates of 3.6%, 6.4%, and 6.4% in Egypt, Turkey, and the Gulf Cluster (Kuwait, Saudi Arabia, and the UAE) [22, 23].

Selected data from different countries in addition to time trends are shown in Table 2.2. Based on these data, the highest reported prevalence of asthma in the years 2010–2019 was 35.4% in children (Iran—single-center study) and 15% in adults (Kuwait—national survey) [24, 25]. The lowest rates reported in children and adults were 8.9% (Turkey) and 1.9% (Kazakhstan), respectively [26, 27]. Given that allergic diseases are predominantly diagnosed for the first time in childhood, the majority of studies in the Middle East have focused on children, using ISAAC guidelines. While the rates of allergic diseases vary among different countries, they do show an anticipated rise in allergic diseases. In Turkey, the same survey repeated in 1994, 2004, and 2014 shows this trend well. The rate of allergic rhinitis, asthma,

Table 2.2 Middle eastern countries

Region	Countries <i>n</i> = 18	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
Middle East	Afghanistan			Asthma: 12.5% (6–7Y) ^{ISAAC} 17.3% (13–14Y) ^{ISAAC}		[221]
	Azerbaijan			Asthma: 2.68% (≥ 18 Y) Current wheeze: 12.3% (≥ 18 Y)		[26]
	Iran	Asthma: 0.71% (6–11 Y) Current wheeze: 3.9% (6–11 Y)	Asthma: 3.9% (6–12 Y) ^a 13.14% (C) ^a 2.7–35.4% (C) ^{ISAAC}	Asthma: 12.2% (5–6 Y) 9.4% (6–7 Y) ^{ISAAC} 3.9% (6–12 Y) ^a 7.5% (6–14) ^{ISAAC} 12.4% (T) ^{ISAAC} 7.6% (18–45 Y) 8.9% (20–44 Y) ^b 7.8% (20–60 Y) 7.95% (GP) ^a	Indoor allergens: house dust mites, feathers, cockroach, pets Outdoor allergens: pollen, grass, willow, insect stings, weeds, Russian thistle Food allergens: cow's milk, eggs (yolk and whites), wheat, honey, walnuts, hazelnuts, tomatoes, sesame, fish, shrimp, pepper, curry	[24, 28, 30, 65, 118, 222–233]
				Current wheeze: 23.3% (T) ^{ISAAC} Allergic rhinitis: 28.5% (5–6 Y) 40.8% (6–7 Y) ^{ISAAC} 28.3% (18–45 Y) 26.7% (A)	Fungal allergens: <i>Aspergillus</i> , <i>Alternaria</i> , <i>Cladosporium</i> , <i>Penicillium</i> Other allergens: nickel, chromium, cobalt	(continued)

Table 2.2 (continued)

Region	Countries <i>n</i> = 18	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
				Allergic rhinoconjunctivitis: 15.9% (18–45Y) Eczema/atopic dermatitis: 15% (5–6Y) 3.9% (18–45Y)		
	Israel		Asthma: 4.5% (17Y)		Other allergens: nickel sulfate, potassium dichromate, fragrance mix	[234, 235]
	Jordan		Asthma: 8.8–9.5% (6–14) ^{ISAAC}	Asthma: 6.2% (T) ^{ISAAC} Current wheeze: 11.7% (T) ^{ISAAC}		[236]
	Kazakhstan			Asthma: 1.9% (≥18Y) Current wheeze: 25.5% (≥18Y)		[26]
	Kuwait	Current wheeze: 16.1% (13–14Y) ^{ISAAC}	Asthma: 15.6% (13–14Y) ^{ISAAC} 16.8% (13–14) ^{ISAAC}	Asthma: 18% (C) ^b 11.9% (18–26Y) 15% (A) ^c Allergic rhinitis: 20.4% (18–26Y)	Outdoor allergens: pollen (especially in high humidity), environmental tobacco smoke	[25, 33, 223, 237–244]

		<p>Current wheeze: 7.6% (13–14Y)^{ISAAC} 16.1% (13–14Y)^{ISAAC} Allergic rhinitis: 22.2% (13–14Y)^{ISAAC} 17.1% (13–14Y)^{ISAAC} Eczema/atopic dermatitis: 12.8% (13–14Y)^{ISAAC} 11.3% (13–14Y)^{ISAAC}</p>	<p>Eczema/atopic dermatitis: 14.9% (T)^{ISAAC} 9.2% (18–26Y) Food allergy (perceived, probable): 12.02%, 5.4% (C-T)</p>	<p>Food allergens: cow's milk, peanut, fish, sesame, egg, wheat, shellfish Other allergens: nickel</p>
Lebanon	<p>Allergic rhinitis: 25.5% (13–14Y)^{ISAAC} Allergic rhinoconjunctivitis: 15.9% (13–4Y)^{ISAAC} Eczema/atopic dermatitis: 11% (13–14Y)^{ISAAC}</p>	<p>Asthma: 8.3% (13–14Y)^{ISAAC} Allergic rhinitis: 45.2% (13–14Y)^{ISAAC} Eczema/atopic dermatitis: 12.8% (13–14Y)^{ISAAC}</p>	<p>Food allergy: 4.1% (C) 3.2% (A)</p>	<p>Indoor allergens: humidity on bedroom walls, spongy pillow, pets, noncotton mattress</p>

(continued)

Table 2.2 (continued)

Region	Countries <i>n</i> = 18	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	Oman	Asthma: 13.8% (6–7Y) ^{ISAAC} Current wheeze: 8.7% (6–7Y) ^{ISAAC}	Asthma: 17.8% (6–7Y) ^{ISAAC} 10.5% (6–7Y) ^{ISAAC} 15.4% (10Y) ^{ISAAC} 20.7% (13–14Y) ^{ISAAC}			[248–250]
			Current wheeze: 13.8% (6–7Y) ^{ISAAC} Allergic rhinitis: 7.4% (6–7Y) ^{ISAAC} 10.5% (13–14Y) ^{ISAAC}			
			Eczema/atopic dermatitis: 7.5% (6–7Y) ^{ISAAC} 14.4% (13–14Y) ^{ISAAC}			
	Pakistan		Asthma: 15.8% (3–16Y) ^{ISAAC} 9.4% (11–15Y) 10.6% (A)	Asthma (self-reported): 10.2% (3–17Y) ^{ISAAC} 1.8% (A)	Indoor allergens: house dust mite, <i>Dermatophagoides farinae</i> , <i>D. pteronyssinus</i> , ill-ventilated kitchens	[63, 119, 251–253]

			Current wheeze: 14.7% (11–15Y) Allergic rhinitis: 28.5% (3–16Y) ^{ISAAC}		Outdoor allergens: pollen Food allergens: wheat, egg, milk, shite lentils, corn, rice, soya, peanut	
			Allergic rhinoconjunctivitis: 15.3% (11–15Y)			
Palestine			Asthma: 8.4% (5–8Y) ^{ISAAC} 9.4% (6–12Y) 5.9% (12–15) ^{ISAAC}			[254, 255]
			Current wheeze: 9.6% (5–8Y) ^{ISAAC} 8.8% (6–12Y) 7.2% (12–15Y) ^{ISAAC}			
Qatar			Asthma: 19.8% (6–14Y) ^{ISAAC} Allergic rhinitis: 30.5% (6–14Y) ^{ISAAC}			[31]
			Eczema/atopic dermatitis: 22.5% (6–14Y) ^{ISAAC}			

(continued)

Table 2.2 (continued)

Region	Countries <i>n</i> = 18	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	Saudi Arabia	Asthma: 6.8% (7–12Y) 8–23% (C) ^{ISAAC}	Asthma: 6.01% (C) ^{ISAAC}	Asthma: 23.6% (6–8Y) ^{ISAAC} 27.5% (C) 14.3% (<16Y) ^{ISAAC, a} 4.05% (>15Y) ^b 19.6% (16–18Y) ^{ISAAC} 11.4% (16–18Y) ^{ISAAC} 11.3% (22–40Y)	Indoor allergens: pets (dogs, dog hair), using wood as cooking fuel	[32, 117, 141, 256–264]
		Allergic rhinitis: 17.9% (7–12Y) 12–17% (7–12Y) 20–25% (C) ^{ISAAC}	Allergic rhinitis: 26.51% (C) ^{ISAAC}	Current wheeze: 18.2% (22–40Y) Allergic rhinitis: 24.2% (6–8Y) ^{ISAAC} 6.3% (C) 21.4% (<16Y) ^{ISAAC, a} 38.6% (16–18Y) ^{ISAAC}	Outdoor allergens: distance from brick factories, exposure to dense truck traffic, pigweed, Bermuda grass	
		Eczema/atopic dermatitis: 10.8% (7–12Y) 12–13% (C) ^{ISAAC}	Eczema/atopic dermatitis: 10.3% (6–8Y) ^{ISAAC} 12.5% (C)		Food allergens: eggs, vegetables Fungal allergens: cladosporium	

Turkey	<p>Asthma: 5% (6–14Y)^{ISAAC} 16.8%–17.4% (6–13) 5.2–5.8% (7–12Y) 16.4% (7–12) 8.1% (7–14Y)</p>	<p>Asthma: 4.6% (6–14Y)^{ISAAC} 12.9% (13–14Y)^{ISAAC} 8.6–12.1% (7–12Y) 3.1–5.3% (A) 4.5% (A)</p>	<p>Asthma: 27.3% (5–6Y) 8.9% (6–14Y)^{ISAAC} 11.9% (C)^{ISAAC} 3.6% (30–49Y) 4.4% (A)</p>	<p>Indoor allergens: living in apartments, more rooms in house (crowding), housing condition (living in shanty-type houses), molds at home, use of wood or biomass for heating or cooking, pets (cats)</p>	<p>[23, 34, 61, 66, 116, 136, 142, 147, 153, 158, 265–278]</p>
	<p>Allergic rhinitis: 18.7–28% (6–13) 8.8% (6–14Y)^{ISAAC} 12.3% (7–12)</p>	<p>Current wheeze: 13.4% (13–14Y)^{ISAAC} Allergic rhinitis: 11.4% (6–14Y)^{ISAAC} 4.3–7% (13–14Y)^{ISAAC}</p>	<p>Current wheeze: 33.3% (5–6Y) 15.8% (9–11Y)^{ISAAC, c} 12.0% (30–49Y) Allergic rhinitis: 8.9% (C)^{ISAAC} 13.4% (5–6Y) 8.1% (6–7Y) 15.6% (6–14Y)^{ISAAC} 14.5% (12–15Y) 4.5% (13–14Y)^{ISAAC} 16.5% (30–49Y) 6.4% (A) 31.0% (9–11Y)</p>	<p>Outdoor allergens: air pollution, bee stings, living at altitude below 1000 m, pollen</p>	

(continued)

Table 2.2 (continued)

Region	Countries <i>n</i> = 18	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
		Eczema/atopic dermatitis: 6.1–6.5% (6–13) 5% (6–14Y) ^{ISAAC} 2.2% (7–12)	Eczema/atopic dermatitis 9.9% (6–14Y) ^{ISAAC} Food allergy 0.3% (GP)	Allergic rhinoconjunctivitis: 23.5% (9–11Y) ^{ISAAC, c} 27.3% (C) ^{ISAAC}	Food allergens: fish, sea food, fermented drinks made from millets and various seeds, animal fats and butter, kiwi, peach, tomatoes, melon and watermelon, cow's milk, eggs, chicken meat, bananas	
				Eczema/atopic dermatitis: 4.3% (1Y) 8.3% (5–6Y) 3.6% (C) ^{ISAAC} 8.1% (9–11Y) ^{ISAAC, c} 8.1% (10–11Y) ^{ISAAC, c} 7% (6–14Y) ^{ISAAC} 9.6% (30–49Y) Food allergy: 6.5% (C) ^{ISAAC}	Other allergens: metal dust, volatile fumes, wood/coal smoke, paper dust	

The superscript ^{ISAAC} indicates studies that have used ISAAC protocol/questionnaires

A adults, *C* children, *E* elderly, *GP* general population, *T* teens, *Y* years

^aResults from systematic review/meta-analysis

^bResults from national surveys

^cResults from multicenter studies

and atopic dermatitis increased from 8.8% to 15.6%, 5% to 8.9%, and 5% to 7%, respectively [27]. Other similar trends are seen in Oman, Iran, Saudi Arabia, and Lebanon (Table 2.2).

Of the different allergic diseases, the highest rates in all Middle Eastern countries belong to allergic rhinitis. In Iran, about 40% of children and 26–28% of adults experience allergic rhinitis independent from or along with asthma [28–30]. Rates as high as 20%, 30%, and 38% have also been reported in Kuwait, Qatar, and Saudi Arabia, respectively [31–33]. Data on food allergy prevalence is lacking in the Middle East; however, the available data show an increase in this category of allergic diseases as well. In Turkey, seafood, fermented drinks made with millets, and animal fats are among common food allergens reported [34]. Peanuts were the most common food allergen in Saudi Arabia, and in Israel, egg, cow's milk, and sesame caused the most number of allergic reactions [35, 36].

Prevalence and Trends of Allergic Diseases: Asia

In general, asthma prevalence is lower in Asian developing countries compared to those in other regions of the world. A range of 1.1–11.0% was found in a systematic review of 74 studies in various regions of China, with the lowest prevalence being observed in Tibet and highest in Hong Kong [37]. Most studies performed in mainland China have used Chinese diagnostic guidelines, yielding a lower prevalence of 3% [37]. Crude prevalence of asthma in India, Sri Lanka, Bangladesh, Nepal, and Pakistan were found to be 6.3%, 5.3%, 5.2%, 4.2%, and 3.7%, respectively [38]. The highest rate of allergic rhinitis was reported for adults in Thailand (37.7%), followed by those in Vietnam (29.6%) [39, 40]. Food allergy prevalence appears to be comparable to prevalence rates observed in Europe and the West, even though the types of foods consumed vary widely [41, 42]. Various seafood are major allergens in the adult population, while eggs and milk commonly affect children. In India, beef and wheat allergies are reported as well. Table 2.3 summarizes results of selected studies performed throughout Asia. Similar to many other developing countries, data from most countries are insufficient, especially in the adult population.

Prevalence and Trends of Allergic Diseases: Latin America

Based on the data available, the highest rate of asthma in adults and children living in Latin American countries is 9.5% (Argentina) and 28.6% (Brazil), respectively, while the lowest rates reported are 4.4% (Brazil) and 6.1% (Mexico) [43–46]. The same increasing trend observed in other developing countries is reported in Latin America as well, although data from most countries excluding Mexico and Brazil are scarce. Selected data from these countries are shown in Table 2.4. As with other

Table 2.3 East Asian countries

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
Asia	Bangladesh	Asthma: 7.3% (5–14Y) 5.3% (15–44Y)				[68]
	China	Asthma: 0.91% (0–14Y) 2.1% (3–7Y) 3.9% (13–14Y) ^{ISAC} 1.8% (>6Y)	Asthma: 1.5% (0–14Y) 1.97% (0–14Y) ^g 1.59% (0–14Y) ^h 0.8% (9–20Y) 4.6–6.9% (13–14Y) ^{ISAC}	Asthma: 4% (0–8Y) 2.09–7.45% (0–14Y) 3.3% (6–13Y) ^{ISAC, a} 2.36% (0–14Y) 2.32% (0–14Y) 3.69% (0–14Y) ^{ISAC} 1.12% (0–14Y) 4.56% (0–14Y) 4.13% (0–14Y) 5.92% (3–6Y) 10.2% (3–7Y) 2.11% (0–14Y) ^h 3.45% (C) 2.9% (C) 1.8% (>6Y) 2.46% (A) 1.25% (≥18) ^c	Indoor allergens: mites, house dust mites, cockroach, pets (dog, cat), pests and visible mold, <i>D. pteronyssinus</i> , <i>D. farina</i> , cooking with gas, foam pillows, damp housing	[75–78, 85, 86, 101, 146, 148, 154, 159, 279–304]

<p>Current wheeze: 3.4% (13–14Y)^{ISAAC} Food allergy: 3.5% (0–2Y)</p>	<p>Current wheeze: 3.4–5.8% (C) 9.3% (2–6Y) 1–7.2% (13–14Y)^{ISAAC} 4.8–6.1% (13–14Y)^{ISAAC}</p>	<p>Allergic rhinitis: 9% (0–8Y) 7.83%–20.42% (0–14Y) 9.8% (6–13Y)^{ISAAC, a} 15.79% (C)^a</p>	<p>Outdoor allergens: pollen, weed pollens, house adjacent to traffic or near pollution source, damaged water source, living near major roads</p>
<p>Current wheeze: 10.8% (3–6Y) 8–21.4% (GP) 1.1–6.3% (13–14Y)^{ISAAC} Food allergy: 7.7% (0–2Y)</p>	<p>Allergic rhinitis: 10.8% (3–6Y) 8–21.4% (GP) 1.1–6.3% (13–14Y)^{ISAAC} Food allergy: 7.7% (0–2Y)</p>	<p>Eczema/atopic dermatitis: 39% (0–8Y) 12.94% (1–7Y) 7.22%–20.64% (0–14Y) 5.5% (6–13Y)^{ISAAC, a} 4.6–10.2% (3–6Y)</p>	<p>Food allergens: egg, cow's milk, wheat, peanut, crab, shellfish, fish, shrimp, oranges, mango</p>
		<p>Food allergy: 3.8% (0–1Y) 5.5–7.3% (0–2Y) 0.3–0.5% (0–14Y)</p>	

(continued)

Table 2.3 (continued)

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	China	<p>Asthma:</p> <p>0.91% (0–14Y) 2.1% (3–7Y) 3.9% (13–14Y)^{ISAAC} 1.8% (>6Y)</p>	<p>Asthma:</p> <p>1.5% (0–14Y) 1.97% (0–14Y)^f 1.59% (0–14Y)^h 0.8% (9–20Y) 4.6–6.9% (13–14Y)^{ISAAC}</p>	<p>Asthma:</p> <p>4% (0–8Y) 2.09–7.45% (0–14Y) 3.3% (6–13Y)^{ISAAC, a} 2.36% (0–14Y) 2.32% (0–14Y) 3.69% (0–14Y)^{ISAAC} 1.12% (0–14Y) 4.56% (0–14Y) 4.13% (0–14Y) 5.92% (3–6Y) 10.2% (3–7Y) 2.11% (0–14Y)^a 3.45% (C) 2.9% (C) 1.8% (>6Y) 2.46% (A) 1.25% (≥18)^f</p>	<p>Indoor allergens: mites, house dust mites, cockroach, pets (dog, cat), pests and visible mold, <i>D. pteronyssinus</i>, <i>D. farina</i>, cooking with gas, foam pillows, damp housing</p>	[75–78, 85, 86, 101, 146, 148, 154, 159, 279–304]
		<p>Current wheeze: 3.4% (13–14Y)^{ISAAC} Food allergy: 3.5% (0–2Y)</p>	<p>Current wheeze: 3.4–5.8% (C) 9.3% (2–6Y) 1–7.2% (13–14Y)^{ISAAC} 4.8–6.1% (13–14Y)^{ISAAC}</p>	<p>Allergic rhinitis: 9% (0–8Y) 7.83%–20.42% (0–14Y) 9.8% (6–13Y)^{ISAAC, a} 15.79% (C)^a</p>	<p>Outdoor allergens: pollen, weed pollens, house adjacent to traffic or near pollution source, damaged water source, living near major roads</p>	

		<p>Allergic rhinitis: 10.8% (3–6Y) 8–21.4% (GP) 1.1–6.3% (13–14Y)^{ISAAC} Food allergy: 7.7% (0–2Y)</p>	<p>Eczema/atopic dermatitis: 39% (0–8Y) 12.94% (1–7Y) 7.22%–20.64% (0–14Y) 5.5% (6–13Y)^{ISAAC, a} 4.6–10.2% (3–6Y) Food allergy: 3.8% (0–1Y) 5.5–7.3% (0–2Y) 0.3–0.5% (0–14Y)</p>	<p>Food allergens: egg, cow’s milk, wheat, peanut, crab, shellfish, fish, shrimp, oranges, mango</p>	
<p>Hong Kong</p>		<p>Current wheeze: 9.6% (2–6Y)^{ISAAC}</p>			<p>[301]</p>
<p>India</p>	<p>Asthma: 15.7% (4–17Y) Current wheeze: 20.8% (4–17Y)</p>	<p>Asthma: 2.3% (6–7Y)^{ISAAC} 3.3% (13–14Y)^{ISAAC} 10.7% (C)^{ISAAC, a} 2.38%^a 4.19% (GP)</p>	<p>Asthma: 1.7% (A) 12.1% (6–15Y) 4.9% (C) 5.49% (GP) 5.35% (6–7Y)^{ISAAC} 6.05% (13–14Y)^{ISAAC} 1.8–1.9% (20–49Y)</p>	<p>Indoor allergens: house dust mite, <i>D. pteronyssinus</i>, <i>D. farinosa</i>, mite antigens, use of biomass, solid fuels and smoke-v- producing fuels at home, pets, absence of smoke outlets</p>	<p>[71, 96, 121–123, 126, 127, 131, 134, 305–313]</p>

(continued)

Table 2.3 (continued)

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
			Current wheeze: 6.2% (6–7Y) ^{ISAAC} 7.8% (13–14Y) ^{ISAAC} 7.3% (7–8) ^{ISAAC}		Outdoor allergens: pollen Food allergens: cow milk, beef–mutton, eggs, banana, brinjal, wheat Chemical allergens: nickel sulfate, <i>Parthenium hysterophorus</i>	
	Laos		Allergic rhinoconjunctivitis: 23.7% (13–14Y) ^{ISAAC} Eczema/atopic dermatitis: 7.1 (13–14Y) ^{ISAAC}			[314]
	Malaysia	Current wheeze: 5.4% (6–7Y) ^{ISAAC} 6% (5–14Y) 6.8%(13–14Y) ^{ISAAC} Allergic rhinitis: 27% (5–14Y)	Asthma: 7.1% (1–5Y) 134% (GP) Current wheeze: 6.2% (1–5Y) 4.3% (6–7Y) ^{ISAAC} 5.7% (13–14Y) ^{ISAAC}		Indoor allergens: house dust mites Outdoor allergens: acacia and Bermuda grass pollens	[120, 145, 315–317]
		Allergic rhinoconjunctivitis: 4.6% (6–7Y) ^{ISAAC} 11% (13–14Y) ^{ISAAC} Eczema/atopic dermatitis: 13.7% (5–7Y) ^{ISAAC} 9.9% (12–14) ^{ISAAC}	Allergic rhinoconjunctivitis: 5% (6–7Y) ^{ISAAC} 15% (13–14Y) ^{ISAAC}		Food allergens: eggs, cow's milk	

Mongolia			<p>Asthma: 4.7% (>20Y) 20.9% (6-7Y)^{ISAAC}</p> <p>Current wheeze: 15.7% (>20Y)</p> <p>Allergic rhinoconjunctivitis: 14.6% (>20Y)</p> <p>Food allergy: 0.33-0.43% (14-16Y)</p> <p>Food allergy: 0.28-0.64% (4-6Y) 0.3-0.47% (14-16)</p> <p>Asthma: 17% (5-17Y)</p> <p>Current wheeze: 21.3% (3-5Y)</p> <p>Allergic rhinitis: 21.4% (5-17Y)</p> <p>Eczema/atopic dermatitis: 5% (5-17Y)</p>	<p>[150, 318]</p>
Philippines			<p>Food allergens: shellfish</p>	<p>[319, 320]</p>
Singapore			<p>Food allergens: peanuts, tree nuts, shellfish</p>	<p>[319, 320]</p>
Sri Lanka			<p>Indoor allergens: combined kitchen/living area, inadequate ventilation in sleeping area</p> <p>Food allergens: wheat</p>	<p>[321-323]</p>

(continued)

Table 2.3 (continued)

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	Thailand	Asthma: 18.3% (6–7Y) ^{ISAAC} 12.7% (13–14Y) ^{ISAAC} Allergic rhinitis: 44.2% (6–7Y) ^{ISAAC} 38.7% (13–14Y) ^{ISAAC}	Asthma: 8.8 (16–31Y) 9.8% (17–53Y) Current wheeze: 14.3% (6–7Y) ^{ISAAC} 9.8% (13–14Y) ^{ISAAC} 10.1% (16–31Y) 12.1% (17–53Y)	Asthma: 16% (20–66Y)	Indoor allergens: house dust mites, cockroaches	[40, 69, 70, 139, 301, 324–327]
		Eczema/atopic dermatitis: 15.4% (6–7Y) ^{ISAAC} 14% (13–14Y) ^{ISAAC}	Allergic rhinitis: 42.6% (6–7Y) ^{ISAAC} 33.3% (13–14Y) ^{ISAAC} 26.3% (16–31Y) 57.4% (17–53Y)	Allergic rhinitis: 37.7% (20–66Y) Food allergy: 9.3% (3–7Y)	Food allergens: shrimp, cow's milk, fish, chicken eggs, ant eggs Chemical allergens: potassium dichromate, nickel sulfate, cobalt chloride, fragrance mix	
			Eczema/atopic dermatitis: 13.5% (6–7Y) ^{ISAAC} 11.2% (13–14Y) ^{ISAAC} 9.4% (16–31Y) 15% (17–53Y) Food allergy: 9.3% (0–3Y)			
	Tibet		Asthma: 1.1% (13–14Y) ^{ISAAC} Current wheeze: 0.8% (13–14Y) ^{ISAAC}			[91]

		<p>Allergic rhinoconjunctivitis: 5.2% (13–14Y)^{ISAAC} Eczema/atopic dermatitis: 0.4% (13–14Y)^{ISAAC} Asthma: 2.4% (A)</p>	<p>Asthma: 3.9–5.6% (21–70Y) 5.1% (6Y) Allergic rhinitis: 10–29.6% (21–70Y)</p>	<p>Indoor allergens: house mites, storage mites, cockroaches Food allergens: crustaceans, fish, mollusk beef, milk, egg</p>	<p>[183, 308, 328–331]</p>
Vietnam			<p>Allergic rhinoconjunctivitis: 11.5% (6Y) Eczema/atopic dermatitis: 6.7% (6Y) Food allergy: 5.7% (A) 5–8.4% (C)</p>		

The superscript ^{ISAAC} indicates studies that have used ISAAC protocol/questionnaires

A adults, C children, E elderly, GP general population, T teens, Y years

^aResults from multicenter studies

^cResults from national surveys

Table 2.4 Latin American countries

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
Latin America	Argentina			<p>Asthma: 9.5% (A)</p> <p>Current wheeze: 13.9% (A)</p> <p>Food allergy (cow milk): 0.8% (C)</p>	<p>Indoor allergens: carpeted rooms</p> <p>Outdoor allergens: living <300 m from an industry</p> <p>Other allergens: wearing synthetic clothes</p>	[43, 51]
	Brazil	<p>Asthma: 4.9–7.3% (6–7Y)^{ISAAC} 9.8–10.2% (13–14Y)^{ISAAC}</p>	<p>Asthma: 20.4% (6–7Y)^{ISAAC} 19.7% (13–14)^{ISAAC} 26.5% (6–14Y) 18.4% (4Y) 23.8% (13–14Y)^{ISAAC} 12.8% (C) 24.3% (6–7Y)^{ISAAC} 19% (13–14Y)^{ISAAC} 16.5–31.2% (6–7Y)^{ISAAC} 11.8–30.5% (13.14Y)^{ISAAC} 15.3% (13–14Y)^{ISAAC}</p>	<p>Asthma: 11.8% (C)^a 11.6% (13–14Y)^{ISAAC} 13.3% (T) 25.2% (C) 15.9% (T) 22% (6–7Y)^{ISAAC} 8.5% (10Y)^f 22.6% (13–14Y)^{ISAAC} 15.3% (13–14Y)^{ISAAC} 7% (5–17Y) 19.1% (13–14Y)^{ISAAC} 9.1% (C) 29.7% (T) 12.4% (T) 25.8% (C) 4.4% (A) 12.8% (13–14Y)^{ISAAC} 28.6% (8–16Y) 20.4% (13–14Y)^{ISAAC}</p>	<p>Indoor/housing allergens: moisture, pets (cats/dog), mold, more number of rooms, <i>D. pteronyssinus</i>, <i>Dermatophagoides farinae</i>, <i>Blomia tropicalis</i></p>	[44, 47, 83, 87, 88, 128, 140, 155, 157, 332–352]

	Current wheeze: 6% (13–14Y) ^{ISAAC}	Current wheeze: 21.1% (4Y) 12.5% (0.5–5Y) 15.8% (13–14Y) ^{ISAAC} 15–19% (13–14Y) ^{ISAAC} 11.7% (C) 31.2% (6–7Y) ^{ISAAC} Allergic rhinitis: 28.8% (6–7Y) ^{ISAAC} 31.7% (13–14Y) ^{ISAAC} 26.6% (6–7Y) ^{ISAAC} 34.2% (13–14Y) ^{ISAAC} 12.2% (13–14Y) ^{ISAAC} 40.7% (13–14Y) ^{ISAAC} 36.6% (13–14Y) ^{ISAAC}	Current wheeze: 44.1% (13–14Y) ^{ISAAC} 6% (20–69Y) Allergic rhinitis: 27.3% (6–7Y) ^{ISAAC} 43.2% (13–14Y) ^{ISAAC} 36.6% (13–14Y) ^{ISAAC} 28.1% (6–7Y) ^{ISAAC} 18.5% (13–14Y) ^{ISAAC}	Outdoor allergens: insects, grasses Food allergens: processed foods, cow's milk
		Allergic rhinoconjunctivitis: 12.6% (6–7Y) ^{ISAAC} 10.3–17.4% (6–7Y) ^{ISAAC} 14.6% (13–14Y) ^{ISAAC} 8.9–28.5% (13–14Y) ^{ISAAC}	Allergic rhinoconjunctivitis: 12.7% (6–7Y) ^{ISAAC} 18.7% (13–14Y) ^{ISAAC} 15.4% (6–7Y) ^{ISAAC}	
		Eczema/atopic dermatitis: 13.6% (13–14Y) ^{ISAAC} 8.2% (6–7Y) ^{ISAAC} 5% (13–14Y) ^{ISAAC}	Eczema/atopic dermatitis: 9.6% (6–7Y) ^{ISAAC} 11.3% (6–7Y) ^{ISAAC} Food allergy: 0.61% (0.5–5Y)	
Chile		Asthma: 9.7–16.5% (6–7Y) ^{ISAAC} 7.3–12.4% (13–14Y) ^{ISAAC} Current wheeze: 16.5–20% (6–7Y) ^{ISAAC} 6.8–11.7% (13–14Y) ^{ISAAC}	Food allergy: 6% (C)	Indoor allergens: mold or dampness in the house [353, 354]
				Outdoor allergens: farm animal contact

(continued)

Table 2.4 (continued)

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
	Colombia	Asthma: 12.2% (GP)	Food allergy: 14.9% (1–83 Y)	Asthma: 9.0% (adults) Current wheeze: 11.9% (adults) Allergic rhinitis: 30.8% (6–7Y) ^{ISAAC} 36.6% (13–14Y) ^{ISAAC}	Indoor allergens: cats	[49, 99, 355–358]
				Allergic rhinoconjunctivitis: 17.2% (6–7Y) ^{ISAAC} 24.9% (13–14Y) ^{ISAAC}	Food/drug allergens: acetaminophen, cereals, eggs, milk, antibiotics in first year of life	
	Costa Rica	Asthma: 23.4% (children) 23.0–27.7% (6–7) ^{ISAAC}	Asthma: 27.1% (10Y) 23.4% (5–17Y)	Asthma: 21.9% (6–13Y) ^{ISAAC} Allergic rhinitis: 42.6% (6–13Y) ^{ISAAC} 27% (6–14)	Indoor allergens: dust, mold, dust mites, cockroach	[48, 79, 129, 137, 359, 360]
	Ecuador			Eczema/atopic dermatitis: 19.2% (6–13Y) ^{ISAAC}	Outdoor allergens: tree pollen	[361, 362]
	El Salvador			Asthma: 10.1% (GP) Current wheeze: 9.4–10.3% (C) Food allergy: 5.7% (C)	Food allergens: milk, shrimp, chili, chocolate, nuts	[50]
	Grenada			Current wheeze: 30.5% (6–7Y) ^{ISAAC}		[363]
	Honduras			Eczema/atopic dermatitis: 28.2% (1Y)		[364]

Jamaica				<p>Asthma: 16.7% (2–17Y)^{ISAAC} Current wheeze: 19.6% (2–17Y)^{ISAAC}</p> <p>Allergic rhinitis: 24.5% (2–17Y)^{ISAAC} Eczema/atopic dermatitis: 17.3% (2–17Y)^{ISAAC}</p>	Indoor allergens: mold, pets (cats and dogs)	[365]
Mexico	<p>Asthma: 8.7% (6–12Y) 34% (6–12Y) 21.8% (6–14Y)^{ISAAC} 5.8% (6–14Y)^{ISAAC}</p>	<p>Asthma: 18% (2–5Y) 4.5% (6–7Y)^{ISAAC} 9.9% (6–7Y)^{ISAAC} 9.1% (6–14Y) 9.5% (9.1Y) 31.8–33.6% (C) 7.4% (C) 8% (13–14Y)^{ISAAC} 7.8% (T)</p>	<p>Asthma: 11.9% (C) 6.1% (C) 7.8% (15–16Y) 12.7% (T) 6.8% (A) 10% (E) Current wheeze: 10.3% (T)</p>	Indoor allergens: pets, indoor plants stuffed toys, dust, dust mites, wall salpeter, dampness (mold growth)	[46, 151, 360, 366–383]	
	<p>Current wheeze: 5.8% (6–14Y)^{ISAAC}</p>	<p>Current wheeze: 6.8% (6–7Y)^{ISAAC} 9.9% (13–14Y)^{ISAAC} 7.3% (T)</p>	<p>Allergic rhinitis: 11.9% (3–15Y) 5.5% (6–12Y) 15% (C) 5.4% (C) 9% (T) 6.9% (A) 60% (E)</p>	Outdoor allergens: contact with farm animals, living close to cement factory, tree pollen		

(continued)

Table 2.4 (continued)

Region	Countries <i>n</i> = 13	Prevalence rates before 1999	Prevalence rates 2000–2009	Prevalence rates 2010–2019	Risk factors/common allergens reported	References
		Allergic rhinitis: 4.9% (6–14Y) ^{ISAAC} Eczema/atopic dermatitis: 4.1% (6–14Y) ^{ISAAC}	Allergic rhinitis: 44% (2–5Y) 4.5% (T) 7.6% (GP) Eczema/atopic dermatitis: 10.1% (6–10Y) 5.4% (11–16Y) 3.8% (T)	Eczema/atopic dermatitis: 3.4% (C) 3% (12Y) 5.2% (T) 3.8% (A) Food allergy: 4.9% (C)	Food allergens: early consumption of cow's milk, early introduction of cereals, egg, beef, pulses, peanuts, sesame, sea food (shellfish, mollusk, fish, shrimp, and crustaceans), strawberries, chocolate, soy, oranges, onion, beans, tomato, lettuce	
	Peru			Asthma: 16.7% (6–18Y) Allergic rhinitis: 18% (13–15Y)	Chemical allergens: Nickel sulfate, palladium chloride, cobalt chloride, potassium dichromate	[98, 384, 385]
	Trinidad and Tobago		Asthma: 12.8–13.5% (11–19Y) ^{ISAAC} Current wheeze: 13.1–13.4% (11–19Y) ^{ISAAC}			[386]

The superscript ^{ISAAC} indicates studies that have used ISAAC protocol/questionnaires

A adults, C children, E elderly, GP general population, T teens, Y years

^aResults from multicenter studies

^cResults from national surveys

countries, allergic rhinitis is the most common allergic disease with rates as high as 43.2%, 42.6%, and 36.6% reported in Brazilian, Costa Rican, and Colombian youth [47–49]. Given the tropical climate of many Latin American countries, dampness, mold, and different fungi commonly trigger allergic reactions. Food allergies range from 0.8% in Argentina to 5.7% in El Salvador, where milk, shrimp, chili, chocolate, and nuts were the most common allergens [50, 51].

Risk Factors and Common Allergens in Developing Countries

So there is evidently an increasing trend in allergic diseases in developing countries, and while risk factors such as gender, age, family history of atopic diseases, and socioeconomic status affect the development of allergic diseases [14, 19, 29, 33, 34, 52–83], these factors have been present at times of lower prevalence rates as well and do not contribute much to the increasing rates over the past few decades. What risk factors do affect allergic diseases then? Probably, those that have changed as a result of urbanization and modernization. Examples of these are increase in caesarian section rates, smoking, obesity, and exposure to air pollutants.

Mode of delivery Birth delivery mode has been shown to affect the rate of allergic diseases [49, 72, 73, 84–88]. More caesarian sections are being performed now compared to past decades, since it seems to be the “modern” way of delivering a child in many countries where it is performed without adequate indication. In 2010, the World Health Organization reported over 6.2 million unnecessary caesarian sections being performed worldwide, 50% of which belonged to China and Brazil [89].

Obesity Greater consumption of high-fat foods and lower physical activity leading to overweight and obesity are also common trends in urbanized societies. Fast food consumption, weight gain, and higher body mass index have been reported to be risk factors of asthma and its related symptoms as well [26, 65, 75, 78, 90–105].

Smoking Most studies in different developing countries have reported higher rates of allergic diseases in urban vs. rural areas [62, 101, 106–115]. Furthermore, many reports have indicated that exposure to tobacco smoking is an important risk factor for asthma [55, 62, 73–75, 77, 78, 81, 90, 92, 93, 95, 96, 116–135]. One interesting observation made in several studies is the effects of maternal smoking on increased allergic diseases in children [72, 73, 88, 121, 136–140]. One possible explanation for this observation is that in many societies, female smoking was previously regarded as a taboo, but it appears that cultures have overcome this taboo and female smoking has become more common in developing countries. The effects of smoking during pregnancy and low-birth-weight children have been extensively studied and proven before, and now higher rates of allergic diseases are observed in children born underweight and to mothers who smoke.

Pet allergy Many of the allergens reported in various countries also reflect modernization features. Pets are a common allergen in many developing countries, as having a pet inside the home (dogs and cats) is more common now [13, 34, 77, 92, 104, 116–118, 121, 127, 132, 134, 140–148]. This can contribute to the increased rate of pet allergy.

Industrial sites and pollution Other allergens of urbanized living reported include living in close proximity of different industries such as cement or brick factories, air pollution, and chemical compounds and volatile fuel that individuals were less commonly exposed to prior to the increase in allergic diseases [13, 79, 82, 148–152]. Living conditions often experienced in urban societies such as apartment living, more crowding in small areas, and crowded day-care attendance have been shown to be associated with higher asthma and its related symptoms as well [56, 61, 68, 76, 151, 153–158].

Now not all modern techniques adversely affect allergic diseases. For example, use of electricity as a cooking method was shown to be a protective factor compared to wood, coal, and other smoke-producing biomass that were previously used for indoor cooking and heating [39, 126, 127, 134, 159].

The High Burden of Allergic Diseases in Developing Countries

As mentioned in the previous sections, the impact of allergic diseases appears to be higher in developing countries in comparison to developed countries, despite of their lower prevalence rates. But why so? There are several reasons for this phenomenon. Lack of knowledge by patients, caregivers, and most importantly physicians is one critical, influential, and preventable factor. Many studies evaluating physicians' ability to identify and manage allergic diseases have reported poor and insufficient knowledge about asthma, its pathophysiology and related symptoms [160–166], delayed or inaccurate diagnosis [167, 168], lack of knowledge about standard medications and guidelines [160, 165, 168–170], and general mismanagement [160, 163–165, 171–175]. In one study evaluating the quality of asthma management, 40% of individuals diagnosed were not informed about their disease, and those who were informed were not given any educational materials [176]. Of course, these extreme cases are uncommon; however, poor physician–patient interactions further affect disease management. Given that the majority of allergic symptoms first develop in childhood, parental knowledge about these diseases and their management is critical, yet in many instances, missing [177–181]. In one study in Africa, parents perceived asthma to be contagious and transmitted from one person to another, while others believed it was transmitted through contaminated food [182]. In Brazil, some parents believed rescue medications may cause their children harm [44]. Research regarding psychosocial factors affecting asthma management in nine Arab countries has also shown parental knowledge to be generally insufficient [179]. Many parents perceive that their children cannot lead nor-

mal lives [175] and these misconceptions adversely affect their children's quality of life as they are often passed down to them, making them believe that they cannot overcome and control their medical condition. Besides social pressures, lack of knowledge in patients leads to noncompliance with therapy [177, 178, 183, 184], exacerbating disease status.

Even when knowledge is adequate, however, other obstacles such as limited resources hinder better care in developing countries. Many times, the most appropriate medications and therapies are not readily available [168, 185], and even when they are, individuals from lower socioeconomic levels are not able to afford them. The economic burden of allergic diseases is a great concern for many countries. The highest costs in various countries are attributed to inpatient and emergency room visits as well as medications [186–188]. In Iran and India, where health care is mostly self-funded, the annual cost per child is very high compared to the average family incomes, draining on family resources [187, 189].

There is a low level of asthma control reported by many developing countries, even those with larger, more rapidly growing economies [184, 186, 187, 190–193]. In China, physicians reported 75% of patients to be well-controlled, while according to Global Initiative for Asthma (GINA) criteria, less than 15% of them were well-controlled [194].

In Qatar, a country with the highest gross domestic product per capita in the world and high health expenditure per capita, 31% and 26% of patients had uncontrolled and partly controlled asthma, respectively, most of which stemmed from incorrect use of inhalers and misunderstanding the role of reliever and controller medications, signifying that the effects of insufficient knowledge on asthma control are greater than the effects economic limitations may have [190]. Allergic diseases in general, but more so uncontrolled asthma, affect individuals' quality of life and cause behavioral and emotional problems in children [44, 167, 179]. They cause school and work absences in 52% of children and 30% of adults in Oman, respectively, and similar patterns are observed in other countries as well [44, 179, 186, 191, 195]. Work productivity, daily activities, and sleep quality are also reported to be low by asthma patients in different developing countries. Although decreased quality of life does pertain not only to developing countries but also to anyone with uncontrolled asthma all over the world, the impact is more significant in low-income developing countries because of the higher rate of uncontrolled asthma observed in these populations.

Allergic Diseases: An Emerging Problem or an Overseen Issue?

So are allergic diseases an emerging problem in low-income and developing countries? Or are they an overseen issue in these populations? The answer appears to be both. Allergic diseases are an emerging problem because of changes in disease pat-

terns and rates over the past few decades, caused by multiple risk factors mainly linked to modernization. The majority of the available data is very recent or only partial, indicating that the issue had been overlooked before and not anticipated in many populations. On the other hand, while there is still a substantial amount of work to be done, most developing countries are now aware of the increasing rate of allergic diseases and are trying to do something about it. For so many years, the greatest health obstacle in developing countries was controlling communicable diseases (still the greatest obstacle in underdeveloped countries), as they caused the highest rates of morbidity and mortality. However, with the global disease trends seen over the past decades, changing from high rates of communicable disease to high noncommunicable diseases, there is a need for change in public health policies in order to better control the burden associated with noncommunicable diseases, including allergic diseases. This change has not yet occurred in many developing countries. Medical and political authorities must get engaged in order to develop adequate resources to manage these problems. As with most things, education definitely plays a major role. Turkey has been a pioneer in conducting different educational workshops targeting different levels of care, from formal educational workshop for physicians to allergy camps for children, all of which have been found to be significantly effective and a great first step for combating the burden of allergic diseases in this country. Similar approaches for the development of infrastructures of education, research, and management are needed throughout the world. These programs need to be culturally sensitive and specific to each population in order to precisely address the needs of each group of people and impact their audience.

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