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Geo-climate effects on asthma and allergic diseases in adults in Turkey: results of PARFAIT study

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The aim of the study was to evaluate the role of geo-climatic factors on the prevalence of allergic diseases in the adult population in Turkey. A total of 25,843 questionnaires using data from parents of 25,843 primary schoolchildren from 14 cities were evaluated. Mean annual temperature was significantly associated with the prevalence of asthma and wheezing in both sexes [respectively; OR: 1.008 (95% CI: 1.003–1.011) and OR: 1.012 (1.006–1.018 in males), OR: 1.007 (1.003–1.012) and OR: 1.01 (1.002–1.018) in females]. In addition, it was associated with eczema in females [OR: 1.007 (1.001–1.012)]. Asthma in females was associated with mean annual humidity in the air [OR: 1.001 (1.000–1.002)]. Annual number of days with snow is associated with wheezing in both sexes [respectively, OR: 1.001 (1.000–1.002) in males and OR: 1.002 (1.000–1.003) in females]. Protective measures could come into priority in certain areas of the country. Allergic diseases may increase as a cause of climate change in the future.

Keywords: allergy; asthma; climate; epidemiology; health

Introduction

The impact of environmental factors on the prevalence of asthma and allergic diseases has become a growing concern throughout the world. To date, various environmental factors have been described for their role in asthma and allergic diseases (King et al. 2004). The role of geo-climatic factors has also been questioned in the aetiology of asthma and allergic diseases. In a large area of Western Europe consisting of 12 countries, climatic differences were reported to be associated with asthma in children (Weiland et al. 2004). The European Community Health Survey analysis has shown that asthma symptoms were associated with outdoor temperature in the adult population for 43 centres from different areas of the world (Verlato et al. 2002). In addition, country-based studies also provided some evidence that asthma was associated with some climatic variables such as higher temperature (Hales et al. 1998) and temperature range (Zanolin et al. 2004). Sparse data about other allergic diseases with regard to geo-climatic factors reported a decrease in allergic rihinitis prevalence with geographical latitude (Wjst et al. 2005) and an increase in symptoms of atopic dermatitis with lower temperatures (Vocks et al. 2001).

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Previous studies have reported that current prevalence ranges from 4.5–9.4% for asthma (Akkurt et al. 2003; Dinmezel et al. 2005), from 17–20% for asthma symptoms (Ozdemir et al. 2000; Akkurt et al. 2003) and from 6.4–27.7% for allergic rhinitis or rhinoconjuctivitis in the adult population in Turkey (Kalyoncu et al. 2001; Dinmezel et al. 2005). A previous study suggested that geographical residence was a risk factor for asthma and wheezing in children (Turktas et al. 2001). Allergic rhinitis and atopic dermatitis were not included in this study. The authors mentioned that residence in northern and southern parts of Turkey was a risk factor for wheezing and asthma, respectively (Turktas et al. 2001). The results of the child part of the Prevalence and Risk Factors of Allergies in Turkey (PARFAIT) study showed that allergic diseases were related to the geo-climatic characteristics of the living area (Kurt et al. 2007). To the best of our knowledge there is no data on the effects of geo-climatic factors on allergic diseases in the adult population in Turkey.

Turkey is located in both Asia and Europe, has coasts on the Mediterranean, Black Sea and the Aegean Sea. Generally, Turkey has a dry sub-continental Mediterranean-type climate which shows variation throughout the country. In fact, Turkey's diverse regions have different climates with the weather system on the coasts contrasting with that prevailing in the interior. Turkey's varied climate is heavily influenced by the presence of the sea to the north, south, and west and by the mountains that cover much of the country. The sea and the mountains produce contrasts between the interior and the coastal parts. Mountains close to the coast prevent Mediterranean influences from extending inland, giving the interior of Turkey a continental climate with distinct seasons. The Aegean and Mediterranean coasts have warm, rainy winters and hot summers. The Black Sea coast receives the greatest amount of rainfall with moderately cold winters. The interior Anatolian Plateau is much more subject to extremes than are the coastal areas and has a continental climate. Winters on the Anatolian plateau are especially long, and cold with increased snow.

The present study, being part of the PARFAIT study, was designed to evaluate the role of geo-climatic factors on the prevalence of allergic diseases in the adult population in Turkey.

Methods

Study population

Fourteen cities were selected from different geo-climatic regions of the country for inclusion in the study. Schools were selected randomly from rural and urban areas of each city. In the current cross-sectional study, questionnaires were distributed to children in the primary schools and completed by the parents at home. Teachers were also informed about the study and helped to increase participation.

Questionnaire

The questionnaire included questions on the educational and social status of subjects and on current (during the previous year) allergic diseases. Prevalence of current asthma, wheezing and allergic diseases were defined by 'yes' responses to the following questions:

> Asthma: Have you had asthma, bronchitis, spastic bronchitis or allergic bronchitis during the past year?

Wheezing: Have you noticed a whistling sound or wheezing/rattle sound from your chest during the past year?

Allergic rhinitis: Did you have seasonal (hay fever) or perennial allergic rhinitis during the past year?

Eczema: Did you have eczema over elbows and/or knees during the past year?

The reliability and validity of the questionnaire had been tested and was appropriate in a previous study (Kalyoncu et al. 2001). The questionnaire in this study included additional questions on living conditions and personal characteristics.

Geoclimatic data was obtained from the General Meteorology Agency, Ministry of Environment and Forest, Government Statistical Institute (www.meteor.gov.tr, www.die.gov.tr, www.cevreorman.gov.tr) and local meteorological offices in each centre. Climatic data was for as average values which were obtained from long-term climatic data for the last 30 years.

Statistical analysis

Association between allergic diseases and geo-climatic factors was tested with a stepwise analysis. At the first step, adjusted prevalence rates for allergic diseases were obtained from logistic regression model. Allergic diseases were considered as dependent variable and coded as absent or present. Prevalence rates were determined by using adjustments which were made according to age groups (for five years), rural/urban residence, education level, presence of social security, and presence of active smoking to avoid socio-economic variations between centres (cities) using the logistic model (Zanolin et al. 2004):

$$\text{Logit}(\pi) = \beta_0 + \beta_1 \text{ rural/urban ratio } + \beta_2 \text{ age groups } + \beta_3 \text{ presence of social security} + \beta \text{ prevalence of smoking} + \varepsilon.$$

Prevalence of allergic diseases was expressed as π. Heterogenity test for prevalence rates was made using Chi-square (χ^2) test.

At the second step, association between adjusted prevalence rates of allergic diseases and geo-climatic variables were determined using $L = \alpha X + \varepsilon$ simple logistic model. Logit (L) was assessed from the first step for each centre and X expressed geo-climatic variables (altitude, mean annual temperature, mean annual rainfall, annual relative humidity and annual number of snow days). Geo-climatic variables were analysed as continuous covariates. Each logit was weighted by inverse of L_i sample variance. Study population in each centre was taken into consideration for weighted correlation. The associations between prevalence of diseases and geo-climatic variables were expressed as odds ratio [$OR = \exp(\alpha)$]. Differences were considered as statistically significant if $p < 0.05$. The data was analysed with SPSS computer program for Windows version 11.0.

Results

Questionnaires from 14 cities were analysed. The present analysis used data from 25,843 parents of primary schoolchildren. A total of 30,000 questionnaires were distributed in all centres. The overall response rate was 92.3%. Of the collected 27,690 questionnaires, 25,843 were appropriate for analysis. Of these, 60.2% were

from urban centres in accordance with the distribution of Turkey's population. Rural/urban distribution ranged from 0.43–1.02 (median 0.64) between the regions. Questionnaires with missing responses which could affect the quality of the data were accepted as inappropriate. Table 1 shows demographic characteristics of the population.

Table 2 shows the adjusted prevalence rates of allergic diseases. In this table centres which have a prevalence rate of above 75% of the median and below 25% of the median can also be seen. Geo-climatic characteristics of each centre are shown in Table 3, which also contains comprehensive data to compare some average and peak conditions together. Table 4 shows the association between allergic diseases and geo-climatic variables in males and females separately.

Mean annual temperature was significantly associated with the prevalence of asthma and wheezing in both sexes. In addition, it was associated with eczema in women. Asthma in women was also associated with mean annual humidity in the air. Mean number of days with snow were associated with wheezing in both sexes.

Table 1. Demographic characteristics of the study group.

Variable	Number (%)	Heterogenity test between centres
n	25843	*p*
Mean ratio of rural/urban (SD)	0.69 (0.16)	$P < 0.001$
(Range)	(0.43–1.02)	
Mean age of females (SD)	35.12 (5.53)	$P < 0.001$
(Range)	(20–65)	
Mean age of males (SD)	39.81 (6.66)	0.10
(Range)	(24–80)	
Education level of females		$P < 0.001$
Illiteracy	3726 (14.5)	
Primary school	13152 (51.1)	
Middle school	2373 (9.2)	
High-school	4326 (16.8)	
University	2140 (8.3)	
Education level of males		$P < 0.001$
Illiteracy	1207 (4.7)	
Primary school	9723 (37.9)	
Middle school	4293 (16.7)	
High-school	6226 (24.2)	
University	4231 (16.5)	
Absence of social security	7982 (31.3)	$P < 0.001$
Ocupation of females		
Housewife	21913 (85.1)	$P < 0.001$
Worker	1060 (4.1)	
Official	1781 (6.9)	
Other	1007 (3.9)	
Occupation of males		
Farmer	6387 (25.0)	$P < 0.001$
Worker	7912 (30.9)	
Official	7126 (27.9)	
Merchant	4141 (16.2)	
Smoking in females	5406 (21.0)	$P < 0.001$
Smoking in males	13587 (52.6)	$P < 0.001$

Table 2. Adjusted prevalence rates of allergic diseases in both sexes.

	Min.	Median	Max.	Heterogenity test between centres	Percentage within 75% value	Centres above 75% value	Percentage within 25% value	Centres below 25% value
Males								
Asthma	5.20%	7.34%	9.75%	$P < 0.001$	8.70%	Samsun, Van, Elazığ	5.68%	İstanbul, Düzce, Isparta
Wheezing	7.00%	12.28%	15.70%	$P < 0.001$	14.04%	Tarsus, Van, Elazığ	9.74%	İstanbul, Isparta, Düzce
Allergic rhinitis	8.20%	13.28%	21.50%	$P < 0.001$	15.69%	Samsun, Van, Elazığ	12.29%	İstanbul, Isparta, Afyon
Eczema	4.63%	8.55%	10.70%	$P < 0.001$	9.55%	Tarsus, Manisa, Samsun	7.32%	Isparta, Eskişehir, İstanbul
Females								
Asthma	7.04%	9.00%	11.65%	$P < 0.001$	11.12%	Denizli, Tarsus, Erzurum	7.34%	İstanbul, Bursa, Eskişehir
Wheezing	7.70%	13.39%	18.00%	$P < 0.001$	15.91%	Erzurum, Samsun, Van	11.14%	Isparta, Afyon, İstanbul
Allergic rhinitis	11.7%	18.76%	22.8%	$P < 0.001$	20.86%	Samsun, Van, Elazığ	17.20%	Isparta, Eskişehir, İstanbul
Eczema	6.40%	10.20%	11.70%	$P < 0.001$	11.12%	Samsun, Manisa, Elazığ	8.14%	Isparta, Eskişehir, İstanbul

Table 3. Geo-climatic characteristics of the centres, 1974–2004.

Centre	Altitude (m)	Mean annual temperature (°C) (Range*)	Mean annual humidity (%) (Range¶)	Mean annual rainfall (mm) (Range§)	Mean numbers of annual snow days (Range#)
Afyon	1034	11 (−2–21)	63 (53–79)	440 (288–613)	42 (20–53)
Bursa	100	14 (4–23)	65 (58–72)	733 (610–889)	20 (12–23)
Denizli	426	16 (5–26)	62 (58–72)	547 (347–783)	3 (0–8)
Elazig	1067	13 (0–21)	53 (48–76)	427 (206–783)	32 (19–76)
Erzurum	1860	6 (−10–16)	64 (40–75)	447 (306–682)	95 (72–118)
Eskisehir	787	11 (0–21)	66 (50–78)	362 (227–478)	30 (16–41)
Isparta	1035	12 (1–21)	61 (55–77)	581 (312–804)	15 (11–20)
Tarsus	5	19 (12–26)	72 (65–77)	647 (302–884)	0
İstanbul	33	14 (7–23)	73 (69–78)	689 (462–886)	9 (3–15)
Kocaeli	10	15 (5–25)	74 (67–76)	826 (683–1180)	14 (6–18)
Manisa	71	17 (7–27)	60 (45–76)	691 (434–1063)	1 (0–3)
Samsun	4	15 (6–25)	76 (74–80)	735 (488–868)	2 (0–4)
Van	1727	9 (−3–18)	50 (43–68)	420 (284–642)	80 (67–130)
Duzce	144	11 (2–22)	71 (69–80)	510 (377–784)	4 (1–5)

*Shows average of minimum and maximum annual temperatures for long years. ¶Shows average of lowest and highest annual values for long years. §Shows the lowest and highest average annual rainfall during long years. #Shows the lowest and highest average annual values during long years.

Allergic rhinitis did not show any association with geo-climatic variables in the study population.

Discussion

This is the first multicentre study evaluating the effects of geo-climatic factors on the prevalence of allergic diseases in the general adult population in Turkey. The study showed that some geo-climatic variables were associated particularly with asthma and wheezing in the adult population.

Worldwide variability of prevalence of allergic diseases could not be explained by genetic susceptibility only. It is well known that allergic diseases occur as a consequence of genetic and environmental interaction. Among environmental factors, macro-environmental characteristics such as geo-climatic differences could be considered as a risk. Confirming this opinion, the role of climatic conditions has been questioned in the aetiology of asthma and allergic diseases. In an International Study of Asthma and Allergies in Childhood (ISAAC) study which enrolled children from 12 countries of Western Europe, climatic differences were found to be associated with asthma (Weiland et al. 2004). They showed that altitude, annual variation of temperature and outdoor humidity were negatively associated with asthma symptoms (Weiland et al. 2004). The child part of the PARFAIT study supported that allergic diseases in children, especially asthma and wheezing, were associated with higher temperature, increased outdoor humidity and lower altitude in Turkey (Kurt et al. 2007). There is less data about the effects of geo-climatic factors in the adult population. Geographical settlement was not considered as a risk factor in a previous study from Finland (Kotaniemi et al. 2002). However, asthma prevalence was significantly affected by climatic and geographical differences even

Table 4. Associations between geo-climatic variables and adjusted prevalence of allergic diseases in males and females.

	Altitude OR (%95 CI)	Mean annual temperature OR (%95 CI)	Mean annual humidity OR (%95 CI)	Mean annual rainfall OR (%95 CI)	Annual number of snow days OR (%95 CI)
Males					
Asthma	1.002 (1.001–0.999)	1.008* (1.011–1.003)	1.001 (1.002–1.000)	0.999 (1.000–0.998)	1.004 (1.001–0.999)
Wheezing	0.999 (1.000–0.999)	1.012* (1.018–1.006)	1.001 (1.002–0.999)	0.999 (1.001–0.999)	1.001* (1.002–1.000)
Allergic rhinitis	0.999 (1.001–0.999)	1.008 (1.018–0.999)	1.001 (1.003–0.999)	0.999 (1.000–0.999)	1.001 (1.002–0.999)
Eczema	0.999 (1.003–0.999)	1.005 (1.011–0.999)	1.000 (1.002–0.999)	0.999 (1.000–0.999)	1.000 (1.001–0.999)
Females					
Asthma	1.000 (1.000–0.999)	1.007* (1.012–1.002)	1.001* (1.002–1.000)	0.999 (1.000–0.999)	1.000 (1.001–0.999)
Wheezing	0.999 (1.000–0.999)	1.010* (1.018–1.002)	1.001 (1.003–0.999)	0.999 (1.000–0.999)	1.002* (1.003–1.000)
Allergic rhinitis	1.000 (1.000–0.999)	1.009 (1.017–1.000)	1.001 (1.003–0.999)	0.999 (1.000–0.999)	1.000 (1.002–0.999)
Eczema	0.999 (1.000–0.995)	1.007* (1.012–1.001)	1.000 (1.002–0.999)	0.999 (1.001–0.999)	1.000 (1.002–0.999)

*$P < 0.05$.

within the same country with increasing prevalence rates at higher annual temperatures, at decreasing latitude and decreasing distance from the sea (Zanolin et al. 2004). Since Turkey has a relatively big surface area, surrounded by sea on three sides and has various geographical characteristics, climatic characteristics vary between the regions. The coastal region is affected mainly by a Mediterranean climate whereas the Anatolian interior has a continental climate.

The results of the present study are in agreement with other research suggesting a high prevalence of asthma at high temperatures (Hales et al. 1998; Zanolin et al. 2004). The reasons for the effect of temperature are unclear. It is possible that higher temperatures are associated with higher levels of allergens such as house dust mites, pollens and moulds. This opinion is consistent with the fact that areas with higher average annual temperatures in Turkey are located mainly on the coastal areas of the country which is affected by a Mediterranean climate and has higher house dust mite levels in contrast to inner regions (Kalpaklioglu et al. 2004). Furthermore, asthmatics from coastal regions have been shown to have a higher frequency of dust mite and pollen sensitivity in contrast to the interior regions of the country (Kalyoncu et al. 1995). A longer pollen season and diversity of pollens may contribute to sensitisation in these areas. In addition to temperature effect on asthma prevalence, previous studies have suggested that cold weather seems to have effects on asthma symptoms and an increased number of attacks in asthmatics (Kotaniemi et al. 2002). Weather effects were mostly studied in the asthmatic population and asthma admissions to emergency rooms have been shown to have seasonal variation. Adult asthmatics showed increased emergency visits with decreasing temperature and increasing humidity (Ivey et al. 2003). In cold temperatures, asthma attacks and respiratory symptoms tended to be increase (Moineddin et al. 2008). Annual temperature is one of the determinants of climate. In addition to temperature and rainfall, we took annual numbers of snow days into investigation as another climatic variable, which was not used in previous studies. Annual number of snow days was associated with wheezing in the present study in both sexes suggesting that the duration of cold weather conditions is related to asthma symptoms in the adult population, supporting previous studies. These results suggested that the factors which affect the prevalence of allergic diseases might not be the same as those that increased the symptoms of the disease.

One of the associated factors for asthma in the present study is outdoor humidity which was associated with asthma prevalence in females. Outdoor humidity is important for its own effect on air inhaled as well as its influence on indoor humidity; which results in infestation of homes with house dust mites, growth of moulds and home dampness which were associated with asthma and respiratory symptoms (Koh and Choi 2002; Kurt et al. 2007). Previous studies suggested that asthma symptoms in children but not in adults were affected by fungal allergen levels in the air (Atkinson et al. 2006). It seems to be very difficult to find a temporal relationship between outdoor humidity and asthma occurrence in the adult population.

Climatic conditions such as temperature and humidity may affect eczema symptoms. Very cold and hot conditions and temperature changes may increase or decrease eczema symptoms in children with eczema (Williams et al. 2004; Kramer et al. 2005). Most published research on eczema has been carried out in children. There is sparse data on eczema in the general adult population. A community-based study in an adult population reported that the prevalence of eczema has geographical variation throughout Europe showing higher prevalence rates in females (Harrop

et al. 2007). The association of outdoor humidity and asthma prevalence with air temperature and eczema in adult females suggested that females might be more susceptible to climatic effects than males.

Most of the previous studies focused on the short-term effects of climatic factors in asthma and allergic diseases. Although we know that asthma and allergic diseases have great variability all over the world, little is known about the effects of long-term climatic characteristics on this variability. This is the first multicentre epidemiological study on the association of long-term climatic factors with allergic diseases in Turkey. Limitations exist, due to its questionnaire-based design. Although the response rate was good for the study, information bias could not be completely ruled out. There were differences originating from different lifestyles and characteristics of the population in the centres. We made adjustments according to age groups, rural/urban residence, level of education, presence of social security and presence of active smoking between centres to avoid variations due to socio-economic differentiation. Other related factors such as indoor environment have been reported in our previous study (Kurt et al. 2009). One of the limitations was to use general data on geo-climate conditions. One reason for this is the more familiar and feasible nature of the general geo-climatic data. The other resason is the lack of detailed climatic data for longer periods. Some other detailed climatic variables are not available for all centres in the present study to obtain accurate data on average values for long periods.

Climate change is also of great concern with regard to allergic diseases in recent years. Climate change as a result of global warming is considered as one of the probable causes of increased allergy prevalence. Pollen-load increase, prolongation of pollen season, thunderstorms and extreme precipitation are all proposed to increase asthma and allergic diseases as a result of climate change and global warming (Shea et al. 2008). Weather changes may affect the airways directly by cooling or irritating them indirectly or by influencing the level of allergens and irritants. Climate change can affect asthma and allergies by creating weather conditions such as heatwaves, extreme weather, temperature change and precipitation which may also cause an increase of air pollutants and sensitivity to allergens (Bernard et al. 2001; D'Amato et al. 2007). Turkey has been affected by climate change during the last decades. Maximum and minimum temperatures, warm days and warm nights have increased all over Turkey while cool days and cool nights have decreased (Sensoy et al. 2007). Projected average increase in summer days was expected to be 59 days in 100 years (Sensoy et al. 2007).

As a result, our study showed that allergic diseases in adults are related to some geo-climatic characteristics of the living area suggesting protective measures could come into priority in certain areas of the country. Our results also emphasised that allergic diseases, especially asthma and their symptoms, may increase as a cause of climate change in the future.

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