Altitude and bronchial asthma in south-western Saudi Arabia

B.R. Al-Ghamdi,[1] A.A. Mahfouz,[2] I. Abdelmoneim,[2] M.Y. Khan[2] and A.A. Daffallah[2]

ربو المرتفعات، والربو القَصَبي في جنوب غرب المملكة العربية السعودية

بدر راشد الغامدي، أحمد عبد الرحمن محفوظ، إسماعيل عبد المنعم، محمد يونس خان، عاصم عبد الرحمن دفع الله

الخلاصة: تم من خلال مسح أجري من منزل إلى منزل، تحري 1325 شخصاً ممن تبلغ أعمارهم 11 سنة فصاعداً، من المسجلين في مركزَيْن للرعاية صحية أولية، يقع أحدهما على مُرْتَفَع والآخر في مستوى سطح البحر، في منطقة عسير، بالمملكة العربية السعودية. وشمل ذلك قياس الوزن والطول ومعدل ذروة الدفع الزفيري. وتبيَّن أن نسبة انتشار الربو القَصَبي في المنطقة الواقعة في مستوى سطح البحر، (وهي 19.5٪) كانت أعلى، بشكل يُعْتَدُّ به إحصائياً، منها في المنطقة المرتفعة (6.9٪) وتبيَّن أن الأمية، وانخفاض الدخل، واستخدام الفحم والخشب للتدفئة، والسكنَ في منزل مبنيٍّ من الطين أو في خيمة، وعدم وجود الكهرباء في المسكن، ووجود الماشية، قد مَثَّلَتْ عوامل اختطار مهمة للإصابة بالربو القصبي (الشُعبي). أما عند إجراء التَحَوُّف اللوجيستي المتعدد المتغيِّرات، فقد تبيَّن أن الارتفاع وحده هو العامل الذي يترابط ترابُطاً يُعْتَدُّ به إحصائياً بالإصابة بالربو القصبي [نسبة الأرجحية المعدلة = 3.94].

ABSTRACT Through a house-to-house survey, 1325 people aged 11+ years registered at 2 primary health care centres (1 at high altitude and 1 at sea level) in Asir region, Saudi Arabia, were interviewed and examined for weight, height and peak expiratory flow rate. The prevalence of bronchial asthma at sea level (19.5%) was significantly higher than at high altitude (6.9%). Illiteracy, low income, use of coal and wood for heating, having a mud or tent house, lack of electricity inside dwellings and presence of sheep were also significant risk factors for bronchial asthma. In multivariate logistic regression, only altitude was found to be significantly associated with bronchial asthma (adjusted odds ratio = 3.94).

Altitude et asthme bronchique dans la région sud-ouest de l'Arabie saoudite

RÉSUMÉ Dans le cadre d'une enquête porte-à-porte menée auprès de 1325 individus âgés de plus de 11 ans et rattachés à deux centres de soins de santé primaires de la région d'Asir en Arabie saoudite, situés l'un en haute altitude et le deuxième au niveau de la mer, un interrogatoire et un examen comportant la mesure du poids corporel, de la taille et du débit expiratoire de pointe ont été pratiqués. La prévalence de l'asthme bronchique au niveau de la mer (19,5 %) s'est avérée significativement supérieure à celle observée en haute altitude (6,9 %). L'illettrisme, la faiblesse des revenus, l'usage de charbon et de bois de chauffage, l'habitat (maisons en terre ou tentes), l'absence d'électricité dans les logements et la présence de moutons sont apparus comme autant de facteurs de risque significatifs d'asthme bronchique. Selon l'analyse de régression logistique multivariée, seule l'altitude était associée de manière significative à l'asthme bronchique (odds ratio ajusté = 3,94).

[1]Department of Internal Medicine (Chest Diseases); [2]Department of Family and Community Medicine, College of Medicine, King Khalid University, Abha, Saudi Arabia (Correspondence to B.R. Al-Ghamdi: bghamdi@yahoo.com).

Received: 05/06/05; accepted: 13/11/05

Introduction

Asthma has received wide public attention in recent years because of increasing mortality and morbidity worldwide [*1*]. In Saudi Arabia, the reported prevalence ranges from 7% in Dammam to 12% in Riyadh [*2,3*].

The Asir region (population 1 200 000) is located in the south-west of Saudi Arabia, covering an area of more than 80 000 km^2. The region extends from the high mountains of Sarawat (with an altitude of 3200 m above sea level) to the Red Sea, and lies a few kilometres from the northern border of neighbouring Yemen. Data regarding the prevalence of bronchial asthma at the community level in Asir region are scarce. The aim of the present work was to study the prevalence of bronchial asthma and related symptoms among a community sample of adults in a high-altitude and a sea-level area of Asir region.

Methods

Sample

Primary health care services in Asir region are provided through a widespread network of 208 primary health care centres (PHCCs). Each PHCC has a well-defined catchment area and population. The present study was carried out in 2 randomly chosen PHCCs (Al-Soka and Maraba). Al-Soka was chosen from a list of PHCCs in high-altitude areas, while Maraba was chosen from a list of PHCCs in sea-level areas.

Al-Soka is composed of 2 major villages, Al-Soka and Al-Shaaf. The total number of families registered in the PHCC is 204 including 1488 persons. Maraba is composed of 5 villages: Maraba, Ablan, Dhele', Ramlan and Etoed and the total number of families registered in the PHCC is 385.

Through a house-to-house survey all families present in the study areas were included. Heads of families were approached initially and their consent for participation in the study was obtained. Subjects aged 11 years and over in each household were identified.

Data collection

Participants were interviewed face-to-face using a pre-designed questionnaire which included data about sociodemographic and environmental conditions and a validated Arabic translation of the International Study of Asthma and Allergies in Childhood Questionnaire (ISAAC) [*1,4*].

The following measurements were taken: weight, height and peak expiratory flow rate (PEFR) using a mini-Wright flow meter. The patient was instructed on how to use it by taking a deep breath, encircling the meter with his or her lips, holding it from below and not touching the moving pointer or blocking the end of it, then exhaling as fast and as strongly as possible. This was repeated 3 times and the highest reading was taken. The predicted values were calculated using the following formulas [*4*]: for males: PEFR = (0.144 height) – (0.024 age) + 0.225; for females: PEFR = (0.090 height) – (0.018 age) + 1.130. The percentage of the predicted value was calculated for each participant. Values below 75% were considered abnormal and in cases with bronchial asthma it indicated the severity of the condition [*4*].

Analysis

The data were coded, validated and analysed using *SPSS* software. Univariate analysis was used. Student *t*-test and the chi-squared test were used as tests of significance at the 5% level. Whenever suitable, the crude odds ratio (OR) and the 95% confidence in-

tervals (95% CI) were used. Multivariate logistic regression analysis was performed to study the association between potential risk factors for bronchial asthma. The maximum likelihood estimates of combined OR and the 95% CI adjusted for confounders were obtained using multiple logistic regression analysis [*5*].

Results

Study population

The present study included 1325 people (response rate of 93.7%) from both areas (754 persons from Al Soka, the high-altitude area and 571 from Maraba, the sea-level area). The age range was from 11 to 78 years with a mean of 31.6 (standard deviation = 20.1) years and a median of 24 years. Adolescents (aged 11–19 years) represented 40% of the study population and the remainder were adults (20+ years). The sample included 626 males and 699 females. No statistically significant differences were found in age between the 2 areas and both sexes.

People living at sea level were found to have a lower socioeconomic status compared with those living at high altitude. The illiteracy rate (70.4%) and the proportion of people working as shepherds (14.4%) were significantly higher among people living at sea level (28.1%) than those living at high altitude (6.8%) (χ^2 = 233.3 and χ^2 = 20.7 respectively, $P < 0.05$). Similarly, people living at sea level were found to have lower monthly income per capita and higher crowding index compared with those living at high altitude.

People living at sea level were found to have worse environmental conditions compared with those living at high altitude. The proportion of people living in mud houses (61.8%) or huts (57.7%) and having sheep in their houses were significantly higher among people living at sea level (11.8%) compared with those living at high altitude (23.0%) (χ^2 = 364.6, and χ^2 = 87.8% respectively, $P < 0.05$). Similarly, people living at sea level were more likely to use wood and coal for heating and cooking, have air-conditioning and have no electricity compared with those living at high altitude.

Prevalence and determinants of bronchial asthma

The study showed that 163 (12.3%) of the study sample had ever suffered from asthma. The prevalence of bronchial asthma at high altitude (6.9%) was significantly lower than the corresponding figure among people living at sea level (19.5%) (χ^2 = 46.6, $P < 0.05$). The study showed that people living at sea level had almost 3 times the risk of suffering bronchial asthma than those living at high altitude (crude OR 3.27, 95% CI: 2.30–4.64).

Table 1 shows the univariate analysis of other potential risk factors determining bronchial asthma in the study population. Adults were found to have a higher risk of developing bronchial asthma compared to adolescents. Other significant sociodemographic risk factors were illiteracy and low monthly income per capita (less than 400 Saudi rials). The table also shows that people using coal and wood for heating purposes had a significantly higher risk of bronchial asthma. Other environmental risk factors identified as significant risk factors for bronchial asthma were: living in a mud or tent house, a lack of electricity inside the dwelling, having air-conditioning and the presence of sheep.

After adjusting all risk factors to each other in a multivariate logistic regression model (Table 2), only altitude was found to be significantly associated with the presence of bronchial asthma (adjusted OR 3.94, 95% CI: 2.07–7.51).

Table 1 **Univariate analysis of potential risk factors for bronchial asthma in the study sample (*n* = 1325)**

Variable	Ever had asthma		Crude OR	95% CI
	No.	%		
Altitude				
Sea level	111	19.5	3.27*	(2.30–4.64)
High altitude	52	6.9		
Age group				
Adult	111	14.0	1.49*	(1.05–2.11)
Adolescent (11–19 years)	52	9.8		
Sex				
Male	82	13.1	1.15	(0.83–1.60)
Female	81	11.6		
Education				
Illiterate	88	14.5	1.46*	(1.05–2.03)
Educated	75	10.4		
Occupation				
Shepherd/farmer	18	13.5	1.13	(0.67–1.91)
Other	145	12.2		
Monthly income per capita				
Low (< 400 SR)	46	17.0	1.65*	(1.14–2.38)
High (> 400 SR)	117	11.1		
Crowding index				
High (4+)	43	14.1	1.23	(0.85–1.79)
Low (< 4)	120	11.8		
Type of house				
Mud/tent	10	17.9	1.59*	(1.12–2.18)
Concrete	153	12.0		
Electricity				
No	42	17.5	1.69*	(1.157–2.47)
Yes	121	11.1		
Heating method				
Wood/coal	31	21.1	2.12*	(1.37–3.27)
Other	132	11.2		
Air-conditioning				
Yes	131	14.9	2.28*	(1.52–3.42)
No	32	7.1		
Cooking method				
Wood/coal	36	15.4	1.38	(0.93–2.06)
Other	127	11.6		
Having sheep in house				
Yes	50	15.7	1.47*	(1.03–2.11)
No	113	11.2		

OR = odds ratio; CI = confidence interval; SR = Saudi rials.
P < 0.05.

Table 2 **Multivariate analysis of potential risk factors for bronchial asthma in the study sample (*n* = 163)**

Variable	Adjusted OR	95% CI
Altitude: sea level versus high altitude	3.94*	2.07–7.51
Age group: adult versus adolescent	1.09	0.96–1.62
Sex: male versus female	1.18	0.84–1.68
Education: illiterate versus educated	0.91	0.61–1.37
Occupation: shepherd/farmer versus other	0.79	0.45–1.41
Monthly income per capita: low (< 400 SR) versus high (> 400 SR)	1.21	0.79–1.86
Crowding index: high (4+) versus low (< 4)	0.68	0.40–1.15
Type of house: mud/tent versus concrete	0.92	0.58–1.46
Electricity: no versus yes	0.95	0.53–1.70
Heating methods: wood/coal versus other	0.88	0.52–1.48
Air conditioners: yes versus no	1.29	0.78–2.16
Cooking method: wood/coal versus other	0.86	0.52–1.43
Having sheep in house: yes versus no	1.78	0.80–1.74

OR = odds ratio; CI = confidence interval; SR = Saudi rials.
P < 0.05.

Severity of bronchial asthma and related symptoms

Among those who had ever had asthma in the previous 12 months, 86.6% had wheeze, 82.5% had sleep disturbance due to wheeze, 77.7% had limitations of their daily activities, 83.5% had wheeze on exercise, 48.5% had wheeze without exercise and 55.8% had dry cough at night. Results of PEFR showed that 42.3% had an abnormal reading (below 75%) indicating severe bronchial asthma.

Table 3 shows the severity of asthma by altitude. Dry cough at night during the previous 12 months was significantly more

Table 3 **Severity of bronchial asthma among study participants ever-suffering asthma, by altitude**

Indicator	High altitude		Sea level		χ^2-value	*P*-value
	No.	%	No.	%		
Sleep disturbance due to wheezes in last 12 months	26	50.0	59	53.2	0.41	NS
Limitation of daily activity due to wheeze in last 12 months	22	42.3	58	52.3	1.401	NS
Wheeze on exercise in last 12 months	23	44.2	63	56.8	2.229	NS
Dry cough at night in last 12 months	21	40.4	70	63.1	7.358	< 0.05
Abnormal PEFR (< 75% of predicted)	25	48.1	44	39.6	1.033	NS
Total ever-suffered asthma	52	100.0	111	100.0	–	–

NS = not significant; PEFR = peak expiratory flow rate.

frequent among people living at sea level (63.1%) compared with those living at high altitude (40.4%) ($P < 0.05$).

Discussion

Bronchial asthma is a common chronic lung disease worldwide. In Saudi Arabia, several studies showed that the prevalence of bronchial asthma is continuously rising with a consequent increase in morbidity and mortality [*3,6–8*]. Epidemiological studies have shown that the prevalence of bronchial asthma varies from region to region within the country [*9–11*]. The present study showed that almost 1 out of every 8 people living in Asir region had ever suffered from asthma (a prevalence of 12.3%). The prevalence of asthmatics in the present study is above the range of 0.4%–9% reported in European, and developing and Arab countries [*1,6*]. The current rate revealed an overall prevalence higher than that reported in other parts of Saudi Arabia (Dammam, Jeddah and Riyadh) [*7–10*]. Different environmental factors may explain this preponderance.

The present study highlights the role of environmental factors, especially altitude, as determinants of bronchial asthma in the Asir region. People living at sea level had almost 4 times the risk to have bronchial asthma compared with those living at high altitude (adjusted OR = 3.94, 95% CI: 2.07–7.51). Similar studies worldwide showed that the prevalence of bronchial asthma in mountains is low compared with that at sea level and that geographical altitude affects the etiological factors for the development of asthma or the triggers of asthma attacks [*12–14*].

Growing concern has focused attention on the role of indoor and outdoor allergens in aggravating the symptoms of the disease. Epidemiological data from several sources suggest that both genetic and environmental factors play key roles in the expression of asthma. There is also a growing body of evidence to suggest that in genetically predisposed individuals a causal relationship exists between exposure to indoor allergens and the development of asthma. One of the recognized indoor allergens is the house-dust mite, which has been identified as an important factor in progressive increases in the prevalence of asthma. The mite content of house dust decreases with increasing elevation in temperate climates. Indeed, at high altitude, house-dust mites cannot survive [*15,16*].

When someone who is allergic to house-dust mites starts wheezing they are experiencing a type 1 hypersensitivity reaction. Type 1 reactions occur rapidly and are mediated by IgE antibodies (to the allergen) which bind strongly to the surface of mast cells in the skin. The synthesis of IgE antibodies is triggered by T-helper cells, which produces a number of inflammatory cytokines in the process. The most important cytokine in these type 1 responses is interleukin [*4*]. When the IgE antibodies bind to mast cells they break open and release histamine, which causes the clinical symptoms. The clinical response usually stops when the allergen is removed or when the inflammatory response is dampened down by antihistamines or anti-inflammatory drugs [*17*].

Asthma is a serious global health problem. People of all ages in countries throughout the world are affected by this chronic airways disorder that can be severe and sometimes fatal. Asthma can be a significant burden on society, not only in terms of health care costs but also of lost productivity, poor quality of life and reduced participation in family life. Asthma symptoms have been shown to be strongly associated with increase risk of emergency room visits, hospitalization and absence from work. The

present study showed that 42% of asthmatics in Asir region have severe asthma. Decision-makers in the region should take the above-mentioned figure into consideration in planning for health service delivery in the region. There is an urgent need for more intensive screening programmes to identify asthma cases at the primary health care level, especially at sea level. Continuing medical education programmes in the region should be tailored to improving the knowledge and skills of health care providers in the region in order to properly manage cases of bronchial asthma.

References

1. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. ***Lancet***, 1998, 351:1225–32.
2. Al Frayh AR et al. Increased prevalence of asthma in Saudi Arabia. ***Annals of allergy, asthma and immunology***, 2001, 86(3):292–6.
3. Al Frayh A, Al Jawadi TQ. Prevalence of asthma among Saudi schoolchildren. ***Saudi medical journal***, 1992:13:521–4.
4. National Scientific Committee of Bronchial Asthma. ***National protocol for the management of asthma.*** Riyadh, Saudi Arabia, Ministry of Health, 2000.
5. Rimm A et al. ***Basic biostatistics in medicine and epidemiology***. New York, Appleton–Century–Crofts, 1980.
6. El-Sharif NA et al. Geographical variations of asthma and asthma symptoms among schoolchildren aged 5 to 8 years and 12 to 15 years in Palestine: the International Study of Asthma and Allergies in Childhood (ISAAC). ***Annals of allergy, asthma & immunology***, 2003, 90(1):63–71.
7. Al-Dawood. K. Peak expiratory flow rate in Saudi schoolboys at Al-Khobar City, Saudi Arabia. ***Saudi medical journal***, 2000, 21(8):789.
8. Al-Ghamdy YS et al. Socioclinical profile of children with asthma in Al-Majmaah Health Province. ***Saudi medical journal***, 2000, 21(9):847–51.
9. Al-Dawood K. Epidemiology of bronchial asthma among school boys in Al-Khobar city, Saudi Arabia: Cross-sectional study. ***Croatian medical journal***, 2000, 41:437–41.
10. Al-Shehri M et al. Screening for asthma associated risk factors among urban school boys in Abha city. ***Saudi medical journal***, 2000, 21:1048–53.
11. El Gamal F et al. Epidemiology of bronchial asthma. ***Saudi medical journal***, 1993, 14:419–23.
12. Gourgoulianis KI et al. The influence of altitude in bronchial asthma. ***Archives of medical researc***h, 2001, 32(5):429–31.
13. Vargas M et al. Asthma and geographical altitude: an inverse relationship in Mexico. ***Journal of asthma***, 1999, 36(6):511–7.
14. Charpin D et al. Asthma and allergy to house-dust mites in populations living in high altitude. ***Chest***, 1999, 93:758–61.
15. Cogo A et al. Bronchial asthma and airway hyperresponsiveness at high altitude. ***Respiration***, 1997, 64(6):444–9.
16. Boner AL et al. Bronchial reactivity in asthmatic children at high and low altitude. ***American journal of respiratory and critical care medicine***, 1995, 151:1194–200.
17. Gotzsche P, Hammarquist C, Burr M. House dust mite control measures in the management of asthma: meta-analysis. ***British medical journal***, 1998, 317:1105–10.