

The Burden of Asthma in Oman

*Nasser Al-Busaidi,¹ Zulfikar Habibulla,¹ Malvika Bhatnagar,² Nabil Al-Lawati,¹ Yaqoub Al-Mahrouqi¹

عبء الربو في سلطنة عمان

ناصر البوسعيدي، ذو الفقار حبيب الله، مالفيكا باهاتانقار، نبيل اللواتي، يعقوب المحروقي

ABSTRACT: Asthma is a common lung disease worldwide, although its prevalence varies from country to country. Oman is ranked in the intermediate range based on results from the International Study of Asthma and Allergies in Childhood. A 2009 study revealed that the majority of asthmatic patients in Oman reported both daytime and nocturnal symptoms, while 30% of adults and 52% of children reported absences from work or school due to their symptoms. Despite these findings, there is little data available on the economic burden of asthma in Oman. The only accessible information is from a 2013 study which concluded that Oman's highest asthma-related costs were attributable to inpatient (55%) and emergency room (25%) visits, while asthma medications contributed to less than 1% of the financial toll. These results indicate a low level of asthma control in Oman, placing a large economic burden on healthcare providers. Therefore, educating asthmatic patients and their families should be prioritised in order to improve the management and related costs of this disease within Oman.

Keywords: Economic Burden of Disease; Asthma; Lung Diseases; Burden of Illness; Oman.

الملخص: الربو هو مرض رئوي شائع في كل أنحاء العالم، غير أن معدل انتشاره يختلف من قطر لآخر. وبحسب نتائج دراسة عالمية عن معدلات انتشار الربو وفرط التحسس (الأرجية) عند الأطفال، يعد معدل انتشار هذه الأمراض في أطفال عمان متوسط المستوى. وأوضحت دراسة نشرت في عام 2009م أن أغلب مرضى الربو في عمان يشكون من أعراض هذا المرض في النهار والليل معا، وأن نحو 30% من البالغين و52% من الأطفال يغيبون عن العمل أو الدراسة بسبب أعراض الربو. ورغم هذه النتائج، إلا أنه لا تتوفر أي معلومات عن العبء الاقتصادي للربو في عمان. وليس هنالك غير مرجع واحد عن هذا الموضوع، والذي أوضح أن عبء الربو في عمان يتمثل في الصرف على المرضى المنومين (55%) وفي غرفة الطوارئ (25%)، ولا تشكل أدوية الربو سوى أقل من 1% من العبء المالي. وتشير هذه الدراسة إلى المستوى المنخفض لمكافحة الربو في عمان، مما يضع عبئا اقتصاديا كبيرا على أكتاف مقدمي الخدمات الصحية. لذا يجب أن تكون عمليات تعليم وإرشاد مرضى الربو من الأولويات، حتى يتحسن التدبير العلاجي للمرض وتقل تكاليفه في عمان.

مفتاح الكلمات: العبء الاقتصادي؛ الربو؛ أمراض الرئة؛ عبء المرض؛ عمان.

THE PATHOPHYSIOLOGY OF ASTHMA INVOLVES an interaction between several cells, such as neutrophils, mast cells, eosinophils and lymphocytes, and their mediators. This interaction gives rise to chronic inflammation of the already hyper-responsive airways resulting in severe yet reversible airflow limitation. This is responsible for the coughing, wheezing, chest tightness and shortness of breath commonly seen in asthmatic patients.¹

Despite an adequate understanding of the underlying mechanism of this disease and the relative ease and availability of treatment, asthma continues to be a major health concern around the world. According to estimates from the World Health Organization, about 300 million of the world's population suffer from asthma.² It is a major contributor of morbidity in both children and adults, and an important cause of mortality as well, causing an estimated 250,000 premature deaths annually.³ It is no surprise then that asthma represents a significant economic burden on

healthcare systems. A study in the USA estimated the annual direct medical expenditure for asthma treatment in 2007 to be \$37.2 billion.⁴

Individuals who have a poor level of control over their asthma may face difficulties not only physiologically, but also psychologically and socio-economically. Therefore, the goal of treatment in these patients is to improve health status, and, in turn, quality of life.

Prevalence of Asthma in Oman

Although no studies have yet been conducted in Oman to determine the prevalence of asthma, Oman was one of the few Gulf Cooperative Council (GCC) countries to participate in the International Study of Asthma and Allergies in Childhood (ISAAC).⁵ The ISAAC Epidemiological Research Program was established in 1991 due to the rise in the prevalence and severity of asthma and allergic disorders, which highlighted the

¹Department of Medicine, Respiratory Unit and ²Internal Medicine Unit, Royal Hospital, Muscat, Oman

*Corresponding Author e-mail: enhsa@hotmail.com and enhsa1966@gmail.com

magnitude of asthma worldwide and sought to discern the factors contributing to its prevalence.⁵

The first phase of the ISAAC Program involved 700,000 children and adolescents from 156 centres in 56 countries, demonstrating the widespread concern associated with asthma and allergic disorders. The data collection methodology involved the use of simple questionnaires, thus allowing an easy comparison of data from different countries.⁶ The results of the study showed that the symptoms of asthma vary largely even in populations that share genetic similarities, thereby suggesting that environmental factors play an important role in the disease pathophysiology.^{7–10}

Several aspects of the environment were incorporated into the ecological data analysis from phase one of ISAAC. Of these, economic development, dietary factors, climate, infections and pollen were implicated as factors contributing to this phenotypical variation.^{11–16} The second phase involved the use of detailed questionnaires with measurements of physiological variables and indoor exposure.¹⁷ The third phase took the form of a cross-sectional survey across several countries, primarily targeting two groups of children aged 6–7 years and 13–14 years, respectively. This was conducted five years after phase one of the ISAAC Program, which served as a baseline.¹⁷

There was a six-year gap between the implementation of these three phases of the ISAAC Program in Oman. During the first two phases, groups of 6–7-year-olds and 13–14-year-olds were involved. The proportion allocations method was used to get national samples, which were arbitrarily chosen from 10 regional areas of Oman.

In phase one of ISAAC, which took place in April 1995, Arabic questionnaires were distributed ($N = 7,625$) of which 4,079 were given to 6–7-year-olds and 3,546 were given to 13–14-year-olds. In phase three, which was conducted in April 2001, questionnaires were again distributed ($N = 8,080$), of which 4,235 were given to 6–7-year-olds and 3,853 were given to the 13–14-year-olds. An ISAAC Arabic asthma video questionnaire was also completed by the 13–14-year-olds.⁷

In 1995, Oman's prevalence rate of reported asthma diagnoses, as seen in phase one of the ISAAC results, was higher in older children (20.7%) than in younger children (10.5%).¹⁸ Among older children, 283 were current wheezers, of which 30% were suffering from sleep-disturbing wheezing at least once a week and 37.5% had had speech-limiting wheezing during the previous year. In younger children, 277 were current wheezers, of which 40.8% had sleep-disturbing wheezing at least once a week while 45.1% had had speech-limiting wheezing during the previous

year. Exercise-induced wheezing was more prevalent among older children (19.2% versus 6.9%; $P < 0.001$).¹⁸

Among the Eastern Mediterranean countries participating in the ISAAC Program, Oman showed the highest prevalence of asthma in children, although it was in the intermediate range of the ISAAC global ranking. Over the three phases, Omani children were found to have a relatively high prevalence of severe asthma symptoms, including sleep disturbances and speech-limiting wheezing.¹⁹ Different results were noted in the prevalence of asthma, its diagnosis and symptoms (depending on the participants' geographical regions in Oman). In the east, the Ash Sharqiyah region scored the highest prevalence of self-reported asthma diagnoses and the presence of all asthma symptoms in both age groups over the six-year period between the first and third ISAAC phases.²⁰ The participants in the younger group displayed a significant increase in the prevalence of wheezing (8.7–13.8%; $P = 0.002$) and asthma diagnoses (13.8–17.8%; $P = 0.046$) over a period of 12 months during ISAAC phase three, while those in the older group showed an increase in nighttime coughing (21.6–27.8%; $P = 0.039$) in the same time frame. None of the other regions were found to have a change in prevalence from that indicated by the initial study in 1995, with some regions even showing a declining trend in a few self-reported asthma symptoms.²¹

A cause for concern is the finding in both ISAAC phase one and two surveys that over 60% of current wheezers reported severe asthma symptoms, even though only 60% reported an asthma diagnosis.^{7–9} This highlights the fact that asthma was not only underdiagnosed in the data collected, but that the symptoms of the condition were poorly recognised with no indication of improvement over time. Oman was not able to formally participate in the full ISAAC phase two protocol due to cost and logistics. However, a similar study using the same questionnaire was conducted, with the addition of a few questions addressing the use of Arabian incense.²²

Arabian incense, which is also called frankincense or *aluban*, is an aromatic resin obtained from trees of the genus *Boswellia*. It is burnt using wood charcoal, which is a common practice in Omani households. A study of *aluban's* effect on asthma symptoms was conducted to investigate the potential risk factors for asthma and allergies in two representative regions of Oman.^{19,22} A total of 2,441 school-going 10-year-olds were used as the target sample, having been selected randomly from public schools in the Muscat ($n = 1,241$) and south Ash Sharqiyah ($n = 1,200$) regions using the stratified multi-stage sampling method. The intention behind selecting these two regions was to

draw a comparison between the potential offending environmental factors that were responsible for the different prevalence rates as seen in phase one. The statistics from the Muscat region can be considered representative of the national average as, being the capital city, it houses individuals from all over the country. The south Ash Sharqiyah region, however, had the highest prevalence rate of all asthma symptoms. The results of this survey showed that the south Ash Sharqiyah region continued to report the highest prevalence of asthma symptoms in Oman. It also identified exposure to Arabian incense as a common trigger for asthma symptoms in Omani children.²²

The Cost of Asthma in Oman Study addressed the prevalence and cost of asthma management in Oman.²³ A revised Delphi method was used to collect the agreement of data estimations from an asthma management expert panel which consisted of 10 expert physicians in asthma management from Oman.^{23–26} One important advantage of this method over a face-to-face group panel method was to obtain information from each involved member without the influence of others on the panel. This study found that the prevalence of asthma in Oman was estimated to be 7.3% of adults (n = 96,470) and 12.7% of children (n = 58,344). Of this group, 95% used governmental healthcare services.²³

Control of Asthma in Oman

Despite an international agreement on the goals of asthma management, available epidemiological statistics from Europe, the USA and other countries indicate that the treatment of patients with asthma is very poor.²⁷

The Asthma Insights and Reality in the Gulf and the Near East (AIRGNE) study was conducted in five countries including Oman, the United Arab Emirates (UAE), Kuwait, Jordan and Lebanon. The study aimed to examine and evaluate asthma characteristics and the quality of asthma management and control in these countries.²⁸ In addition, the study was intended to define asthma management and evaluate how closely the Global Initiative for Asthma (GINA) guidelines were being followed.²⁹ The AIRGNE study also assessed other aspects of asthma, such as patient knowledge and perceptions of asthma symptoms.²⁸

In Oman, the AIRGNE study was performed in the most populated cities including Muscat (and the areas) Seeb and Mutrah, Sohar and Nizwa. The sampling was designed by gender and age within each city.²⁸ Asthmatic patients reported that they had experienced significant daytime asthma symptoms (68%) and nocturnal symptoms (51%) in the previous four weeks.

The participants also reported frequent use of health facilities in the previous year with frequent emergency room (ER) visits (52%) and hospitalisations (23%) leading to work and school absences. Lung function testing was generally underemployed, with 66% never having undergone a lung function test. Peak expiratory flow was used only by a small proportion of the patients and only 17% owned their own peak flow meters.²⁸

The overall AIRGNE results showed that the level of asthma control in the studied countries lagged far behind the GINA guidelines for asthma management.^{28,29} However, there were differences in the level of control in each country. In Oman, there were wide-ranging discrepancies in asthma perceptions. While 57% of asthmatics perceived their asthma symptoms as “well or completely controlled”, 54% had “poorly or not well-controlled” asthma. Advice issued for asthma control by GINA was mostly disregarded, especially in children, evidenced by the fact that 44% cited nocturnal awakenings due to asthma symptoms in the previous four weeks and 47% recalled exercise-induced asthma symptoms in the previous year. These incidents led to a large number of patients reporting asthma-related school/work absences in the preceding year (32.6% of children and 34.8% of adults).²⁸

One finding of concern was that only 5% of Omani asthmatics were found to be using preventive medications in the form of inhaled corticosteroids (ICS). This figure was one of the lowest in the studied countries, evidenced by an improper ratio of ICS to short-acting beta-agonists (ICS/SABA) of 0.054 among Omani asthmatic patients.³⁰

Although the results of the AIRGNE study were eye-opening, they were comparable to those of a study conducted in Oman in 2009.³¹ In this study, the authors evaluated the level of asthma control among patients visiting the Chest Clinic in the Royal Hospital in Muscat, Oman, using the Asthma Control Test™ (QualityMetric Inc., Lincoln, Rhode Island, USA). The results of the study revealed that 61% of asthma patients scored between 20 and 25, classifying their asthma as well controlled. However, 17.7% scored between 15 and 19, indicating that their asthma was not well controlled. The remainder of patients (21.3%) scored between 5 and 14, signifying that their asthma was poorly controlled. Half of the patients stated that their asthma had a large impact on their work, school or home lives.³¹ A large number of patients (66%) reported nighttime symptoms and 70% had used rescue medications such as albuterol in the previous four weeks. The results showed that patients also had an inaccurate perception of their asthma severity; the majority of patients (65%) stated that their asthma was well controlled but in reality their symptoms

limited their daily activities and caused frequent nocturnal awakenings.³¹

Moreover, a recent study on the cost of asthma in Oman showed that inpatient and ER visits accounted for the majority of overall asthma costs (55% and 25%, respectively), thereby indicating poor control of asthma in Oman.²³

Cost of Asthma Care in Oman

There are currently no accurate governmental data or studies that directly address the issue of the cost of asthma care in Oman. However in 2013, Al-Busaidi *et al.* reported the general cost of asthma in Oman following a study that was conducted using a modified version of the Delphi method.²³ The results of the study were as follows: hospital stays and ER visits contributed to the majority of asthma-related costs in Oman (55% and 25%, respectively), whereas outpatient visits and asthma medications accounted for 20%. In fact, it was found that medication accounted for less than 0.2% of the total direct cost of asthma. The annual amount spent on asthma management in Oman, excluding medication, was found to be Omani riyals 34,273,696 for adults and OMR 27,014,735 for children.²³ It can be assumed that when inpatient and ER visits account for a large portion of the total cost of asthma management, there is a strong correlation with poor asthma control, which in turn leads to a potential burden on Oman's Ministry of Health (MOH).

Factors Leading to the Varying Asthma Prevalence in Oman

The ISAAC studies found that asthma symptoms were common in Oman and significant differences were seen in the prevalence of asthma and its symptoms in different regions, with the Ash Sharqiyah region reporting the highest prevalence.^{18,20,21} The reason for these findings remains unknown. However, many aspects of the environment were evaluated in the environmental and biological assessment in phase one. Certain factors might influence the variation seen in the prevalence of the disease and its symptoms. These factors include economic development, dietary factors, climate, infections and pollen levels.^{11–16} It would be beneficial to conduct a study in the Ash Sharqiyah region to elucidate the risk factors contributing to these regional variations. The investigation of these factors would also help in developing a national plan of health and environmental strategies to control asthma.¹⁸

The national estimation of the prevalence of asthma in 6–7-year-olds is 10.5%. This, therefore,

puts Oman at the intermediate prevalence level on the ISAAC's international scale for the same age group.⁸ However, among 13–14-year-olds, Oman had the highest prevalence of asthma (20.7%) of the seven Eastern Mediterranean countries in the ISAAC study. In comparison, the following countries had a lower prevalence: Iran (2.7%), Kuwait (17.5%), Lebanon (11.7%), Malta (11.1%), Morocco (11.7%) and Pakistan (7.3%).³²

In 13–14-year-olds, the prevalence of asthma diagnoses and the self-reporting of asthma symptoms was higher compared to the younger age group.⁸ The most likely reason for this is a cumulative effect—asthma which starts early in childhood persists into adolescence and, in addition, new cases are diagnosed during adolescence.¹⁸

A Regional View of Oman's Asthma Control Levels

The AIRGNE study was the first and most comprehensive survey of the current state of asthma management in the region. The results of this study revealed that the current level of asthma control in the region was not up to standard and that Oman's levels were far below the goals outlined by the GINA guidelines for long-term asthma management.³⁰ There are several aspects of asthma management and control in Oman that are as poor or poorer than other parts of the world.²⁷ The AIRGNE study showed that asthma morbidity in Oman was elevated, with an unacceptably high dependence on the use of rescue medications.³⁰ Several causes have been attributed to this, including the poor detection of uncontrolled asthma by doctors; inaccurate perceptions by patients of the severity of their asthma symptoms; underutilisation of preventive asthma medications, namely ICS; poor asthma education provided to patients and their families, and the very small percentage of asthmatic patients undergoing a lung function test for a diagnosis or the monitoring of their asthma control levels.³⁰

Asthma is poorly managed in Oman as compared to other regions analysed in the different Asthma Insights and Reality studies.^{28,30} Based on the results of the AIRGNE survey, 54% of asthmatic patients in Oman have uncontrolled or not well controlled asthmas according to the definition outlined in the GINA guidelines.^{29,30} The Asthma Insight and Reality in Europe (AIRE) and AIRGNE studies both showed that approximately 50% of adult patients had daytime symptoms. Generally, the average rate of inadequate asthma control in the AIRGNE countries (68%) was found to be unacceptably high and this rate was even higher in Oman (71%).^{28,30} These findings were

similar to those of Al Rawas *et al.*, which showed that nearly 60% of all current wheezers among Omani schoolchildren noted the presence of at least one asthma symptom, indicating severe or uncontrolled asthma.²¹

The AIRGNE survey revealed that nocturnal disturbances were also found to be common in Oman (44%).³⁰ This finding parallels that of Al-Riyami *et al.*, where the frequency of sleep disturbance in Oman was nearly four times that in Iran (3.5% versus 0.9%), twice that of Malta (3.5% versus 1.5%) and greater than that of Australia (3.5% versus 2.8%).²⁰

Based on the results of AIRGNE, the frequency of hospitalisations and ER visits in Oman reported in the year before the study was conducted was unacceptably high (30% and 58%, respectively), while the existing use of preventive medications for asthma, namely ICS, was unacceptably low.^{28,30} The use of ICS in asthma patients in Oman was only 5%, which was significantly and statistically lower than the average reported in the other countries included in the AIRGNE study (14.6%; $P < 0.05$). The daily use of rescue medications in Oman was extraordinarily high compared to that of other AIRGNE countries (92% versus 55.5%, respectively).³⁰

A large number of asthmatic patients in Oman overrated their level of asthma control and underrated the severity of their disease, as indicated by the discrepancy in their subjective perceptions compared to objective asthma severity.²⁸ Of the patients with asthma, 57% perceived their symptoms as well or completely controlled. However, 54% had poorly or not well controlled asthma as assessed by the Asthma Control Test™ (QualityMetric Inc.) ($P < 0.05$). The lung function test is considered an important test for asthma diagnosis and level monitoring. Omani asthmatics' performances were very low as only 35% of patients stated that they had done a lung function test and only 25% had their own peak flow meter.³⁰

Generally, in comparison to other AIRGNE countries, Oman had on average the worst asthma management as reflected by the very high use of rescue medications, the very low number of prescriptions for ICS and an unacceptably high frequency of asthma-related visits to the ER.³⁰

A Global View of Oman's Total Asthma Costs

Al-Busaidi *et al.* found that the cost of asthma management resulted in a significant economic load on the healthcare system in Oman.²³ Their study found the total cost of asthma to be OMR 61,500,293 per year. Hospital stays and ER visits were the factors that mainly drove this expenditure, equating to almost 80% of direct costs. In contrast, the cost of asthma

medications was negligible, representing less than 1% of the total direct cost of asthma.²³

The AIRGNE study determined that 21% of Omani asthmatic adults and children had visited the ER in the year before the study.³⁰ In comparison, in the AIRE study, only 10% of asthmatic patients reported visiting the ER in the year before the study.³² The AIRGNE study also reported that, in the year prior to the study, 30% required overnight hospital stays, in comparison to 7% in the AIRE study.^{30,32} Inpatient stays and ER visits are both linked directly to poorer levels of asthma control, which leads to a larger cost liability on the MOH.²³

The annual direct cost of asthma in Europe was found to be €7.9 billion distributed between outpatient treatment (48%), drug costs (46%) and inpatient care (6%).³³ Similarly, in the USA, drug prescriptions and outpatient visits accounted for the majority of costs, comprising nearly 38% of the total cost for asthma in children and 49% of the cost in adults.³⁴ The larger share of expenses for inpatient care and ER visits for asthmatics in Oman appears to reveal a lower level of asthma control in contrast to that of asthmatics in Europe and the USA.

Recommendations for Reducing the Burden of Asthma in Oman

Asthma morbidity is largely preventable. It appears that this fact is not widely known in Oman, suggesting the need to improve levels of understanding and communication between asthmatic patients and their doctors. Among physicians, there should be an emphasis on following the GINA guidelines to achieve and monitor asthma control among all patients.²⁹ The authors suggest that the most effective way to reach this objective is to promote thorough education for all asthmatic patients and their families, including information on the regular use of preventative steroid inhalers.

Conclusion

The WHO estimates that more than 300 million people have asthma worldwide, although there are noteworthy discrepancies in its prevalence between countries. In Oman, the asthma prevalence is relatively high compared to other countries in the region. In addition, Oman features regional discrepancies in asthma prevalence, with Ash Sharqiyah playing host to the highest rate of asthma in the country. The reason for this discrepancy is not clear and there is a need for further research in order to help with future

health strategic plans. The high number of asthma-related ER visits and admissions to hospital reflect the poor control of the condition in Oman. Therefore, closely following the GINA guidelines and educating asthmatic patients and their families should be prioritised in order to improve the management and related costs of this disease within Oman.

References

- Global Initiative for Asthma. Pocket Guide for Asthma Management and Prevention. From: www.ginasthma.org/documents/1/Pocket-Guide-for-Asthma-Management-and-Prevention Accessed: Oct 2014.
- Bousquet J, Kiley J, Bateman ED, Viegi G, Cruz AA, Khaltaev N, et al. Prioritised research agenda for prevention and control of chronic respiratory diseases. *Eur Respir J* 2010; 36:995–1001. doi: 10.1183/09031936.00012610.
- Bousquet J, Khaltaev N; Global Alliance against Chronic Respiratory Diseases. Global Surveillance, Prevention and Control of Chronic Respiratory Diseases: A comprehensive approach. From: www.who.int/gard/publications/GARD_Manual/en/ Accessed: Oct 2014
- Kamble S, Bharmal M. Incremental direct expenditure of treating asthma in the United States. *J Asthma* 2009; 46:73–80. doi: 10.1080/02770900802503107.
- Asher MI, Keil U, Anderson HR, Beasley R, Crane J, Martinez F, et al. International Study of Asthma and Allergies in Childhood (ISAAC): Rationale and methods. *Eur Respir J* 1995; 8:483–91. doi: 10.1183/09031936.95.08030483.
- Enarson DA. Fostering a spirit of critical thinking: The ISAAC story. *Int J Tuberc Lung Dis* 2005; 9:1.
- The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and atopic eczema: ISAAC. *Lancet* 1998; 351:1225–32. doi: 10.1016/S0140-6736(97)07302-9.
- Worldwide variations in the prevalence of asthma symptoms: The International Study of Asthma and Allergies in Childhood (ISAAC). *Eur Respir J* 1998; 12:315–35. doi: 10.1183/09031936.98.12020315.
- Strachan D, Sibbald B, Weiland S, Ait-Khaled N, Anabwani G, Anderson HR, et al. Worldwide variations in prevalence of symptoms of allergic rhinoconjunctivitis in children: The International Study of Asthma and Allergies in Childhood (ISAAC). *Pediatr Allergy Immunol* 1997; 8:161–76. doi: 10.1111/j.1399-3038.1997.tb00156.x.
- Williams H, Robertson C, Stewart A, Ait-Khaled N, Anabwani G, Anderson HR, et al. Worldwide variations in the prevalence of symptoms of atopic eczema in the International Study of Asthma and Allergies in Childhood. *J Allergy Clin Immunol* 1999; 103:125–38. doi: 10.1016/S0091-6749(99)70536-1.
- Stewart AW, Mitchell EA, Pearce N, Strachan DP, Weiland SK; International Study for Asthma and Allergy in Childhood Steering Committee. The relationship of per capita gross national product to the prevalence of symptoms of asthma and other atopic diseases in children (ISAAC). *Int J Epidemiol* 2001; 30:173–9. doi: 10.1093/ije/30.1.173.
- Weiland SK, von Mutius E, Hüsing A, Asher MI; International Study for Asthma and Allergy in Childhood Steering Committee. Intake of trans fatty acids and prevalence of childhood asthma and allergies in Europe. *Lancet* 1999; 353:2040–1. doi: 10.1016/S0140-6736(99)01609-8.
- Ellwood P, Asher MI, Björkstén B, Burr M, Pearce N, Robertson CF; International Study for Asthma and Allergy in Childhood Phase One Study Group. Diet and asthma, allergic rhinoconjunctivitis and atopic eczema symptom prevalence: An ecological analysis of the International Study of Asthma and Allergies in Childhood (ISAAC) data. *Eur Respir J* 2001; 17:436–43.
- Weiland S, Hüsing A, Strachan D, Rzehak P, Pearce N. Climate and the prevalence of symptoms of asthma, allergic rhinitis, and atopic eczema in children. *Occup Environ Med* 2004; 61:609–15. doi: 10.1136/oem.2002.006809.
- von Mutius E, Pearce N, Beasley R, Cheng S, von Ehrenstein O, Björkstén B, et al. International patterns of tuberculosis and the prevalence of symptoms of asthma, rhinitis and eczema. *Thorax* 2000; 55:449–53. doi: 10.1136/thorax.55.6.449.
- Burr ML, Emberlin JC, Treu R, Cheng S, Pearce NE; International Study for Asthma and Allergy in Childhood Phase One Study Group. Pollen counts in relation to the prevalence of allergic rhinoconjunctivitis, asthma and atopic eczema in the International Study of Asthma and Allergies in Childhood (ISAAC). *Clin Exp Allergy* 2003; 33:1675–80. doi: 10.1111/j.1365-2222.2003.01816.x.
- Ellwood P, Asher MI, Beasley R, Clayton TO, Stewart AW; International Study for Asthma and Allergy in Childhood Steering Committee. The International Study of Asthma and Allergies in Childhood (ISAAC): Phase three rationale and methods. *Int J Tuberc Lung Dis* 2005; 9:10–6.
- Al-Riyami BM, Al-Rawas OA, Al-Riyami AA, Jasim LG, Mohammed AJ. A relatively high prevalence and severity of asthma, allergic rhinitis and atopic eczema in schoolchildren in the Sultanate of Oman. *Respirology* 2003; 8:69–76. doi: 10.1046/j.1440-1843.2003.00426.x.
- The International Study of Asthma and Allergies in Childhood: The ISAAC story. Sultanate of Oman, Eastern Mediterranean. From: isaac.auckland.ac.nz/story/centres/countries.php?cen=66 Accessed: Oct 2014.
- Al-Riyami BM, Al-Rawas OA, Al-Riyami AA, Jasim LG, Mohammed AJ. Prevalence of asthma symptoms in Omani schoolchildren. *J Sci Res Med Sci* 2001; 3:21–7.
- Al-Rawas OA, Al-Riyami BM, Al-Kindy H, Al-Maniri AA, Al-Riyami AA. Regional variation in the prevalence of asthma symptoms among Omani school children. *Sultan Qaboos Univ Med J* 2008; 8:157–64.
- Al-Rawas OA, Al-Maniri AA, Al-Riyami BM. Home exposure to Arabian incense (bakhour) and asthma symptoms in children: A community survey in Oman. *BMC Pulmonary Medicine* 2009; 9:23. doi: 10.1186/1471-2466-9-23.
- Al-Busaidi NH, Habibullah Z, Soriano JB. The asthma cost in Oman. *Sultan Qaboos Univ Med J* 2013; 13:218–23.
- Rosengart MR, Nathens AB, Schiff MA. The identification of criteria to evaluate prehospital trauma care using the Delphi technique. *J Trauma* 2007; 62:708–13. doi: 10.1097/01.ta.0000197150.07714.c2
- Bramwell L, Hykawy E. The Delphi Technique: A possible tool for predicting future events in nursing education. *Nurs Pap* 1974; 6:23–32.
- Kumaran KM, Lemieux M, Satchell G. Problem solving with the Delphi technique. *Dimens Health Serv* 1976; 53:34–5.
- Rabe KF, Adachi M, Lai CK, Soriano JB, Vermeire PA, Weiss KB, et al. Worldwide severity and control of asthma in children and adults: The global asthma insights and reality surveys. *J Allergy Clin Immunol* 2004; 114:40–7. doi: 10.1016/j.jaci.2004.04.042.
- Khadadah M, Mahboub B, Al-Busaidi NH, Sliman N, Soriano JB, Bahous J. Asthma insights and reality in the Gulf and the near East. *Int J Tuberc Lung Dis* 2009; 13:1015–22.

29. Bateman ED, Hurd SS, Barnes PJ, Bousquet J, Drazen JM, FitzGerald M, et al. Global strategy for asthma management and prevention: GINA executive summary. *Eur Respir J* 2008; 31:143–78. doi: 10.1183/09031936.00138707.
30. Al-Busaidi N, Soriano JB. National results within the Asthma Insights and Reality in the Gulf and the Near East (AIRGNE) study. *Sultan Qaboos Univ Med J* 2011; 11:45–51.
31. Al Busaidi N, Al Mukhaini S. Level control of asthma patients in chest specialist clinics. *Oman Med J* 2009; 24: 195–8. doi: 10.5001/omj.2009.38.
32. Rabe KF, Vermeire PA, Soriano JB, Maier WC. Clinical management of asthma in 1999: The Asthma Insights and Reality in Europe (AIRE) study. *Eur Respir J* 2000; 16:802–7.
33. European Respiratory Society. *European Lung White Book*. Sheffield, UK: European Respiratory Society, 2003.
34. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002–2007. *J Allergy Clin Immunol* 2011; 127:145–52. doi: 10.1016/j.jaci.2010.10.020.