The burden of asthma among children and adolescents in Saudi Arabia: A national cross-sectional survey

Shaker A. Alomary, MD,[a] Wael A. Althagafi, MD,[a] Ahmed J. Al Madani, MBBS,[a] Izzeldin F. Adam, BPH, MPH, PhD,[a,b] Omneya E. Elsherif, PhD,[a,c] Aljoharah A. Al-Abdullaah, BSc,[a] Hamdan H. Aljahdali, MD,[d] Hani A. Jokhdar, MBBCh, MSc, PhD,[e] Saeed H. Alqahtani, MD,[a] Mahmoud A. Nahhas, BS Pharm, MPH, PhD,[f]* Rasha A. Alfawaz, PhD,[a] and Abdullah A. Alangari, MD[g]

Riyadh, Saudi Arabia; Khartoum, Sudan; and Cairo, Egypt

Background: Asthma disease is one of the most common chronic diseases of childhood. Studies assessing asthma prevalence in Saudi Arabia have been variable and not recently updated.

Objectives: We sought to assess asthma prevalence, severity, and related risk factors among children and adolescents in Saudi Arabia.

Methods: A national, cross-sectional design was used following the Global Asthma Network phase I design. A total of 3817 children aged 6 to 7 years and 4138 adolescents aged 13 to 14 years were recruited from 137 primary and 140 intermediate schools across 20 regions by using a multistage stratified cluster sampling technique. Standardized written questionnaires were answered by the adolescents and by the parents or guardians of the children. The adolescents also answered a video-based questionnaire.

Results: Overall, the prevalences of current wheeze were 10.4% and 13.3% and the prevalences of asthma ever were 13.8% and 15.7%, % in children and adolescents, respectively. Of all the children and adolescents, 5.2% and 5.6% had symptoms of severe asthma, respectively. Among those who reported asthma, 86.0% of the children and 74.8% of the adolescents had their asthma confirmed by a doctor, and 53.0% and 32.4%, respectively, were provided with a written plan to control their asthma. The main risk factors associated with current wheeze included antibiotic use in the first year of life, a history of being diagnosed with pneumonia in children, paracetamol use, and having a cat at home during the past 12 months in adolescents.

Conclusions: The prevalence of asthma in children and adolescents in Saudi Arabia is within the average international range and is at a plateau phase. (J Allergy Clin Immunol Global 2022;1:241-7.)

Key words: *Asthma, prevalence, children, adolescents, GAN phase I, Saudi Arabia, risk factors, current wheeze, asthma ever*

Asthma is a chronic inflammatory disease of the airways that is associated with variable and at least partially reversible bronchoconstriction. It is among the most common chronic diseases in childhood.[1] Asthma prevalence is defined as the proportion of a population with asthma at a particular time, usually in a 1-year period, because asthma symptoms are mostly intermittent. Studying the prevalence of asthma and determining whether it is rising or declining is important for health care resource planning and for identifying disease origins and factors controlling its epidemiology. Several studies from the United States, Europe, and Taiwan have revealed that the overall prevalence of asthma increased 2- to 3-fold from the 1960s to the 1990s.[2-6] A recent report from Finland looking at data compiled during health examinations of young men for compulsory military service revealed that the prevalence of asthma in 18- to 19-year-old men increased linearly from 0.29% in 1966 to 3.44% in 2001 and then continued to rise at a much slower rate, reaching 5.19% in 2017.[7]

There is no perfect measure to determine asthma prevalence in epidemiologic surveys. This has contributed to the variability of results from different studies evaluating prevalence owing to the different methods used. To avoid this, the International Study of Asthma and Allergies in Childhood (ISAAC) was developed in the early 1990s, providing a standardized way to estimate the prevalence of asthma symptoms.[8]

The Global Asthma Network (GAN) was established in 2012 as a development of ISAAC phase 3 to evaluate the changing asthma burden globally in both children and adolescents, examine variation in the diagnosis and prevalence of asthma between different nations, and (it is hoped) identify potential remedial asthma risk factors.[9,10] The diagnosis of asthma is typically based on an overall assessment that includes history, examination, lung function measures, and response to bronchodilators. However, the application of this approach in large epidemiologic surveys is not practical. On the basis of different studies, it has been determined that inquiring about wheezing as a particular asthma symptom over the past 12 months is a reasonably sensitive and specific

From [a]the General Directorate of Health Programs and Chronic Diseases, [e]the Deputyship of Public Health, and [f]the General Administration of School Health, Ministry of Health, Riyadh; [b]the Department of Epidemiology, University of Khartoum; [c]Department of Family Medicine, Cairo University Hospitals; [d]the Department of Medicine-Pulmonary Division, King Saud Bin Abdulaziz University for Health Sciences, Riyadh; and [g]the Department of Pediatrics, College of Medicine, King Saud University, Riyadh.

*Mahmoud A. Nahhas is currently a public health consultant in Riyadh.

Supported by the Saudi Arabian Ministry of Health.

Disclosure of potential conflict of interest: The authors declare that they have no relevant conflicts of interest.

Received for publication April 11, 2022; revised June 9, 2022; accepted for publication July 31, 2022.

Available online September 7, 2022.

Corresponding author: Wael A Althagafi, MD, General Directorate of Health Programs and Chronic Diseases Ministry of Health, Riyadh 13245-7518, Saudi Arabia. E-mail: waalthagafi@moh.gov.sa. Or: Abdullah A. Alangari, MD, Department of Pediatrics, College of Medicine, King Saud University, Saudi Arabia. E-mail: aangari@ksu.edu.sa.

The CrossMark symbol notifies online readers when updates have been made to the article such as errata or minor corrections

2772-8293

https://doi.org/10.1016/j.jacig.2022.07.006

Abbreviations used
GAN: Global Asthma Network
ICS: Inhaled corticosteroid
ISAAC: International Study of Asthma and Allergies in Childhood

way to assess asthma prevalence at the population level,[11] capture almost all asthmatic individuals, and minimize recall error.[12]

In Saudia Arabia, small-scale studies using different data collection methodologies, sampling frameworks, measurements, and case definitions were conducted in some regions. Hence, obtaining nationwide and up-to-date information on asthma prevalence by using validated instruments is highly needed. To accomplish this, we conducted a national cross-sectional survey, using globally recognized tools and a standardized methodology based on the ISAAC approach to investigate the current prevalence of asthma, severity, and related risk factors among children and adolescents in Saudia Arabia.[8]

METHODS

Study design, setting, and population

A cross-sectional survey was conducted in primary and intermediate schools in Saudi Arabia from March 2019 to April 2020. The study population comprised 2 groups of schoolchildren: a group aged 6 to 7 years (first and second primary grades) and a group aged 13 to 14 years (first and second intermediate grades). Both Saudi and non-Saudi schoolchildren were included as observation units with their parents or guardians (for both groups).

Sample size and sampling technique

The sample size was calculated for each age group separately by using a confidence interval of 95%, a prevalence of 50%, and a margin of error of 1.5%. Given the study population size for each age group (742,118 for the group aged 6-7 years and 683,317 for the group aged 13-14 years) and considering an additional value of 10% for nonresponse rate, the calculated sample sizes for the 2 age groups were 4669 and 4666, respectively, yielding a total of 9335 schoolchildren. Ideally, to estimate asthma prevalence with good precision, 3000 individuals per age group are required in surveys to detect a difference with a statistical power greater than 90% at a significance level of 1%.[8]

The sampling process was implemented separately for primary and intermediate schoolchildren. The sample size was proportionally allocated in 20 administrative regions of Saudi Arabia. A multistage sampling method beginning with stratification based on region, sex, and type of school (public or private) was used. An online random picker was used to select schools within each region according to their Ministry of Education unique identifier code. In total, 277 schools (137 primary and 140 intermediate) were randomly selected from all regions for governmental schools and from 7 major regions for private schools owing to the relatively very small number of schoolchildren in other regions. Cluster sizes of 40 and 30 schoolchildren were selected from each governmental and private school, respectively. Simple random sampling was used to select the participants within each school.

The questionnaire

Data were collected through a structured, self-administered questionnaire that was nationally validated following recommended GAN procedures. The core questions are the same as those used in phases 1 and 3 of ISAAC and the GAN.[9] The questionnaire consists of demographic data, including school-related information, date of birth, nationality, and sex. It also assesses the prevalence and severity of asthma and explores asthma management and environmental factors in both age groups (6-7 and 13-14 years). The questions are sensitive and specific and have good predictive validity.[13] Asthma prevalence or "current wheeze" was determined on the basis of the question "Has your child had wheezing or whistling in the chest in the past 12 months?" for the 6- to 7-year-old children and the question "Have you had wheezing or whistling in the chest in the past 12 months?" for the 13- to 14-year-old adolescents. Severe asthma was defined by the existence of current wheeze (wheeze in the past 12 months) and 4 or more attacks of wheeze, 1 night or more per week of sleep disturbance from wheeze, or wheeze affecting speech in the past 12 months. The questionnaires were self-administered for adolescents (13-14 years), whereas the parents or guardians were invited to answer the questionnaires for the children (6-7 years). For both age groups, the parents or guardians were also asked to complete a questionnaire inquiring about their own health. Along with the written questionnaire, a video-based questionnaire with nonverbal scenes of asthma symptoms was shown to the adolescents before they answered the questionnaire.

Data handling and quality

The data were entered into Microsoft Excel sheets, and weekly data validation was conducted to ensure the quality of the entered data. For data validation, 10% of all entered data were reentered by an independent individual. Subsequently, a third person compared the original and reentered data. The percentage of errors was less than 5% in both age groups, which is within an acceptable level of accuracy.

Statistical analysis

Data analysis was done using IBM SPSS Statistics for Windows, version 26 (IBM Corp, Armonk, NY). All analyses were performed after cleaning the data and excluding missing or skipped responses. Demographics were presented in frequency tables. Associations between categoric dependent and independent variables were assessed by using chi-square analysis. Statistical significance was set at $P < .05$. Logistic regression analysis was used to identify significant factors associated with asthma prevalence. First, bivariate logistic models were used to estimate the strength of association between individual predictors and the prevalence of asthma. Then, multivariable models were used to identify independent risk factors after adjusting for potential confounders.

Ethical considerations

The central institutional review board in the Saudi Ministry of Health approved the study protocol (approval reference no. H-01-R-009). Further permission was also given by the Ministry of Education before the school visits and data collection. Participation in this survey was entirely voluntary, and consent was obtained from the participants who agreed to join the survey or their guardians. All recorded files were kept in a locked room to ensure complete confidentiality. Participants were anonymized and assigned identification numbers.

RESULTS

Data were collected from 3817 schoolchildren aged 6 to 7 years and 4138 aged 13 to 14 years, representing 81.8% and 88.7% response rates, respectively (Fig 1). The sociodemographic characteristics of the schoolchildren by age group are summarized in Table I. The percentage of girls was only slightly higher than that of boys in both age groups (51.3% and 50.5%, respectively).

Table II shows the prevalence and severity of asthma symptoms and asthma control among schoolchildren. The prevalence of current wheeze was 10.4% in children aged 6 to 7 years and 13.3% in adolescents aged 13 to 14 years. In the video questionnaire, 11.9% of the adolescents reported having a current wheeze. Of the children and adolescents, 5.2% and 5.6% had symptoms of severe asthma, respectively, and among those who reported current wheeze, the rates were 49.9% and 41.8% respectively. The

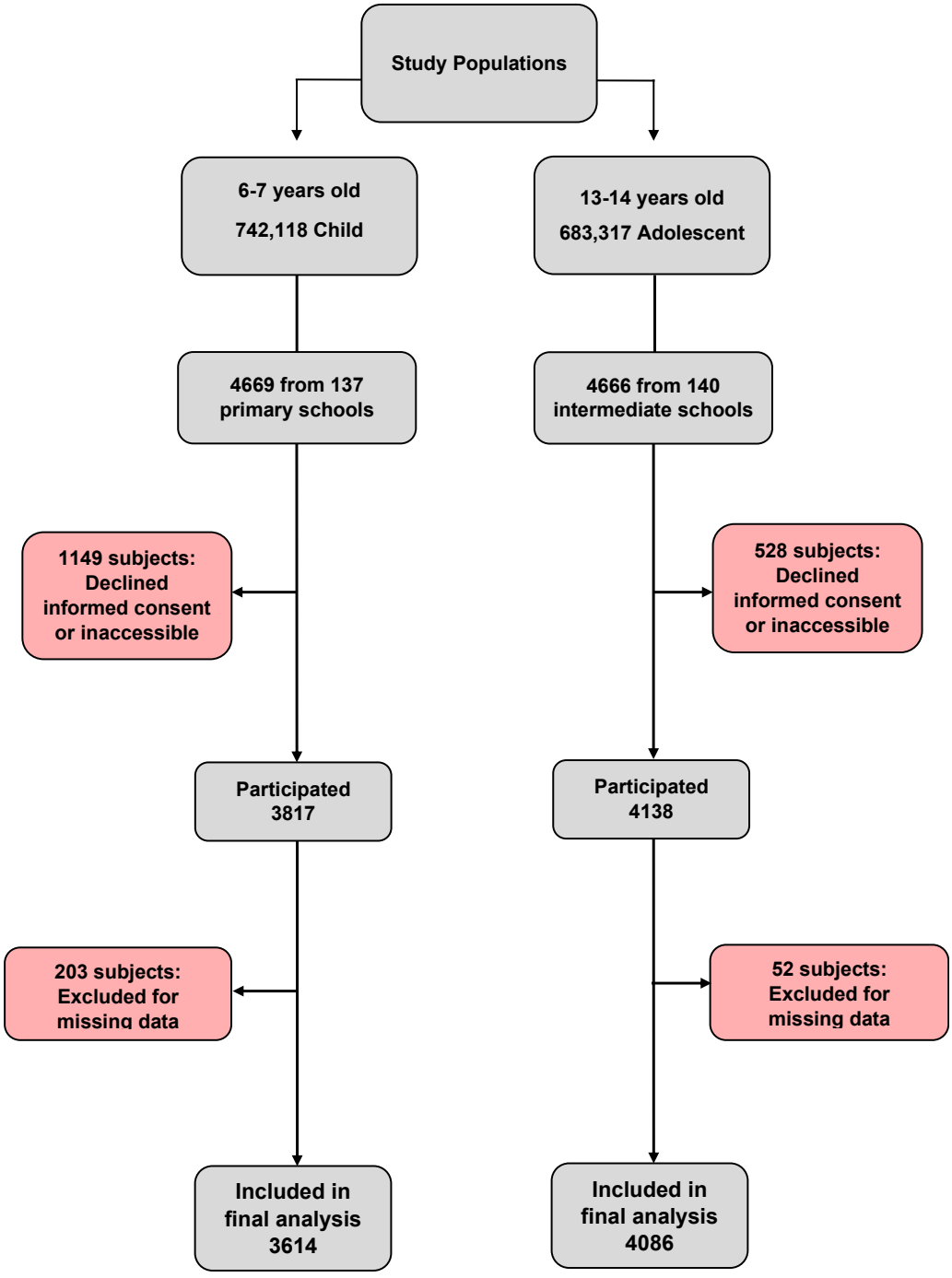

FIG 1. Study flow diagram.

prevalence of current wheeze was significantly higher in boys than in girls (11.5% vs 9.6% [$P < .05$] among those aged 6-7 years and 16.1% vs 10.4% [$P < .001$] among those aged 13-14 years). An estimated 6.7% of children and 19.1% of adolescents reported that their chest sounded wheezy during or after exercise, whereas 19.0% and 25.7%, respectively, reported night cough in the past 12 months.

Asthma ever (ever having asthma) was reported by 13.8% of the 6- to 7-year-olds and 15.7% of the 13- to 14-year-olds. Of those, 86.0% and 74.8%, respectively, reported that their asthma status was confirmed by a medical doctor; more than half of the children (53.0%) and nearly one-third of the adolescents (32.4%) reported having a written plan for asthma control (Table II).

The associations between current wheeze and asthma ever, asthma diagnosed by a doctor, and having a written plan for asthma control are shown in Table III. The percentage of asthma ever was significantly higher among schoolchildren who reported current wheeze than among those who did not (56.8% vs 8.7% [$P < .001$] in the children and 49.0% vs 10.2% [$P < .001$] in the adolescents). The percentage of schoolchildren who reported

TABLE I. Sociodemographic characteristics of the participating schoolchildren

Characteristic	Age group	
	6-7 y (n = 3614)	13-14 y (n = 4086)
Age (y), mean ± SD	6.9 ± 0.5	13.4 ± 0.6
Sex, no. (%)		
Boys	1673 (48.7)	1973 (49.5)
Girls	1764 (51.3)	2015 (50.5)
Twins, no. (%)	96 (2.8)	114 (2.9)
Weight at birth (kg), mean ± SD	3.3 ± 0.4	NA
Weight (kg), mean ± SD	21.7 ± 4.4	48.7 ± 11.7
Height (m), mean ± SD	1.2 ± 0.1	1.5 ± 0.1
Older siblings (no.), mean ± SD	2.2 ± 2.3	2.7 ± 2.9
Younger siblings (no.), mean ± SD	1.1± 0.9	2.2 ± 1.7

NA, Not available.

TABLE II. Prevalence and severity of asthma symptoms in schoolchildren

Symptom	Aged 6-7 y				Aged 13-14 y			
	Total (n = 3614) No. (%)	Boys (n = 1673) No. (%)	Girls (n = 1764) No. (%)	*P* value	Total (n = 4086) No. (%)	Boys (n = 1973) No. (%)	Girls (n = 2015) No. (%)	*P* value
Current wheeze*	377 (10.4)	193 (11.5)	169 (9.6)	.045	543 (13.3)	318 (16.1)	210 (10.4)	<.001
Symptoms of severe asthma, no.†	188	100	88		227	139	79	
% of all	5.2	5.9	4.9	.760	5.6	7.0	3.9	.135
% of wheeze	49.9	51.8	52.1	.880	41.8	43.3	37.1	.170
Exercise wheeze in the past 12 months, no. (%)	242 (6.7)	119 (7.1)	111 (6.3)	.117	781 (19.1)	458 (23.2)	298 (14.8)	<.001
Night cough in the past 12 months, no. (%)	685 (19.0)	310 (18.5)	344 (19.5)	.837	1051 (25.7)	509 (25.8)	513 (25.5)	.593
Asthma ever	500 (13.8)	254 (15.2)	229 (13.0)	.001	643 (15.7)	380 (19.3)	243 (12.1)	<.001
Asthma confirmed by a doctor, no.	429	221	192		474	282	179	
% of all	11.9	13.2	10.9	.093	11.6	14.3	8.9	<.001
% of asthma ever	86.0	87.4	83.8	.272	74.8	75.2	74.3	.796
A written plan for asthma control, no.	259	121	129		198	114	76	
% of all	7.2	7.2	7.3	.056	4.8	5.8	3.8	<.001
% of asthma ever	53.0	49.0	57.1	.078	32.4	32.0	32.3	.935

P values were obtained from chi-square tests comparing categoric variables in boys and girls.
*Participants with wheeze in the past 12 months (percentages were calculated for all participants).
†Participants with wheeze in the past 12 months who had 4 or more attacks of wheeze, at least 1 night per week of sleep disturbance due to wheeze, or wheeze affecting speech.

that their asthma had been confirmed by a doctor was also significantly higher among those who reported current wheeze than among those who did not (91.4% vs 81.7% [$P < .01$] in the children and 82.8% vs 69.1% [$P < .001$] in the adolescents). This was also true for having a written plan for asthma control: more children and adolescents reporting current wheeze also reported having a written plan (among the children, a written asthma plan was reported by 61.1% of those reporting current wheeze vs by 45.9% of those not reporting current wheeze [$P < .01$], and among the adolescents, a written asthma plan was reported by 37.5% of those reporting current wheeze vs by 28.6% of those not reporting current wheeze [$P < .05$]).

Table IV illustrates the use of inhalers among the children and adolescents during the past 12 months. The vast majority of schoolchildren in both age groups used short-acting β-agonists, inhaled corticosteroids (ICSs), and combination therapy of ICS and long acting β-agonists only when needed. The results suggest that adherence to ICS or combination therapy is very low.

Adjusted factors associated with current wheeze in schoolchildren aged 6 to 7 years are shown in Table V. Notably, children who used antibiotics during the first year of life or those who had ever been diagnosed with pneumonia were significantly more likely to develop current wheeze than were those who did not. Adjusted factors associated with current wheeze in adolescents aged 13 to 14 years are shown in Table VI. Notably, children who took paracetamol (at least once per month) or those who had a cat in the home during the past 12 months were significantly more likely to develop current wheeze than those who did not.

DISCUSSION

This is the first national study that is part of a major GAN survey assessing the prevalence of asthma in schoolchildren in Saudi Arabia. The response rate for the 2 age groups was greater than 80% (with almost equal numbers of male and female participants). The prevalence of asthma symptoms in the past 12 months, current wheeze, was estimated to be 10.4% among the children and 13.3% among the adolescents. These figures are similar to the mean global prevalence rates for asthma symptoms

TABLE III. Association between the prevalence of current wheeze and having asthma ever, asthma diagnosed by a doctor, and an asthma management plan

Variable	Current wheeze* (aged 6-7 y) Total (n = 3614) No. (%)	Yes (n = 377) No. (%)	No (n = 3143) No. (%)	*P* value	Current wheeze* (aged 13-14 y) Total (n = 4086) No. (%)	Yes (n = 543) No. (%)	No (n = 3404) No. (%)	*P* value
Asthma ever	500 (13.8)	214 (56.8)	274 (8.7)	<.001	643 (15.7)	266 (49.0)	346 (10.2)	<.001
Asthma confirmed by a doctor, no.	429	192	228		474	217	237	
% of all	11.9%	50.9%	7.3%	<.001	11.6%	40.0%	7.0%	<.001
% of asthma ever	86.0%	91.4%	81.7%	.002	74.8%	82.8%	69.1%	<.001
A written plan for asthma control, no.	259	127	124		198	96	94	
% of all	7.2%	33.7%	3.9%	<.001	4.8%	17.7%	2.8%	<.001
% of asthma ever	53.0%	61.1%	45.9%	.001	32.4%	37.5%	28.6%	.022

P values were obtained from chi-square tests comparing categoric variables in the current wheeze and nonwheeze groups.
*Wheeze during the past 12 months for all participants.

TABLE IV. Use of inhalers among children and adolescents with breathing problems during the past 12 months

Inhaler type	Aged 6-7 y (n = 3614) No. (%)	Aged 13-14 y (n = 4086) No. (%)
Short-acting β-agonist	n=211	n=636
Only when needed	151 (71.6)	521 (81.9)
Short course	51 (24.2)	98 (15.4)
Daily	9 (4.3)	17 (2.7)
ICS	n=117	n=463
Only when needed	86 (73.5)	396 (85.5)
Short course	24 (20.5)	55 (11.9)
Daily	7 (6.0)	12 (2.6)
Combination therapy*	n=120	n=463
Only when needed	82 (68.3)	385 (83.2)
Short course	33 (27.5)	57 (12.3)
Daily	5 (4.2)	21 (4.5)

*Combination of ICSs and long-acting β-agonists.

reported 15 years ago in ISAAC phase 3 (11.6% and 13.7% in children and adolescents, respectively)[14,15] and slightly higher than the mean prevalence in the current GAN phase I report.[16] The video questionnaire yielded a prevalence of current wheeze of 11.9% in adolescents, which is similar to the result from the written questionnaire, giving more assurance of the data and obviating translation issues. The rates of asthma ever were 13.8% and 15.7% among children and adolescents, respectively. These percentages are higher than those for current wheeze, which is not surprising because some preschool asthmatic children will outgrow their symptoms and some are not truly asthmatic.[17] About 80% of children with asthma ever had their asthma confirmed by a doctor, indicating good access to medical care. However, only one-third to one-half of them have a written asthma action plan, which is too low a proportion.[18] Regarding asthma symptom severity, about 40% to 50% were found to have severe asthma symptoms according to the GAN definition. Although these numbers are similar to the averages from the countries participating in the GAN,[16] they suggest poor asthma control. This is supported by data on asthma inhaler use. There is a small, albeit concerning, percentage of patients who are using short-acting β-agonists on a daily basis. In addition, more than 80% of asthmatic children and adolescents are using an ICS only when needed, indicating poor adherence. More efforts need to be taken to promote management optimization and appropriate early referral to asthma specialists.

We also found asthma to be more prevalent in boys than in girls, which is consistent with data on prepubertal patients from the United States and Europe.[19,20]

Moreover, exercise-induced wheeze was found to be more prevalent in adolescents than in children and it was particularly common in boys in both age groups. This is to be expected because adolescent boys usually get more intense and prolonged exercise than the other groups do. The video questionnaire yielded a prevalence of current wheeze similar to the result from the written questionnaire, giving more assurance of the data and preventing translation issues. Parents of the participating children and adolescents (6367 parents) had a current wheeze prevalence of 14.2%,[21] which is within the expected range for this population.

Many centers and countries have participated in the GAN phase I study (2015-2020). Published data from Mexico showed current wheeze prevalences of 10.2% and 11.6% in children and adolescents, respectively.[22] Published data from Bangkok, Thailand, showed the prevalences of current wheeze to be 14.6% and 12.5% in similar age groups, respectively.[23] Also, a study from Salamanca, Spain, that involved only adolescents showed a prevalence of 14.7%.[24] These numbers are not very different from those of our study.

Several studies assessing asthma prevalence in Saudi Arabia or some of its regions have been published during the past 35 years; some of them adopted the ISAAC questionnaire or a modified version of it.[25-28] The measured asthma prevalence rates varied widely between these studies, probably owing to the variation in sample size, geographic area, or method used to conduct the study or analyze the data. A recent meta-analysis of local studies[29] showed asthma prevalence in Saudi Arabia to be 13.3%, revealing an increase from 10.3% over a 20-year period. This is consistent with the results of our study, and it shows that the prevalence of asthma symptoms is at a plateau phase similar to the worldwide trend estimated previously by ISAAC phase 3, particularly in Western countries.[15]

Among the risk factors associated with current wheeze in children was the use of antibiotics during the first year of life, which is consistent with the ISAAC phase 3 findings[30] and the

TABLE V. Logistic regression analysis of risk factors associated with current wheeze among schoolchildren aged 6 to 7 years

Risk factor	Current wheeze* (n= 3520)	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex		
Boys	Reference	Reference
Girls	0.8 (0.6-1.0)†	0.7 (0.5-0.9)‡
Child born prematurely		
No	Reference	Reference
Yes	2.2 (1.6-3.2)§	1.6 (1.0-2.4)†
Child ever breast-fed		
No	Reference	Reference
Yes	0.9 (0.7-1.2)	0.9 (0.7-1.3)
Antibiotics used in the first year of life		
No	Reference	Reference
Yes	2.3 (1.8-2.9)§	1.8 (1.4-2.3)§
Had a cat in the home during the first year of the child's life		
No	Reference	Reference
Yes	1.5 (0.9-2.6)	1.0 (0.5-2.0)
Child was laid on sheepskin in infancy		
No	Reference	Reference
Yes	4.1 (2.2-7.8)§	2.4 (1.1-5.2)†*
Ever diagnosed with pneumonia		
No	Reference	Reference
Yes	8.2 (6.1-11.0)§	6.3 (4.5-8.8)§
Trucks pass through neighborhood		
Never	Reference	Reference
Seldom	1.4 (1.1-1.9)‡	1.3 (0.9-1.7)
Frequently throughout the day	1.6 (1.1-2.4)†	1.3 (0.8-2.2)
Almost the whole day	1.8 (1.0-3.2)†	1.8 (1.0-3.5)

Adjustment was performed for all variables listed.
OR, Odds ratio.
*Wheeze during the past 12 months for all participants.
†$P < .05$.
‡$P < .01$.
§$P < .001$.

TABLE VI. Logistic regression analysis of risk factors associated with current wheeze among schoolchildren 13- to 14-years old

Risk factor	Current wheeze* (n= 3947)	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex		
Boys	Reference	Reference
Girls	0.6 (.5-0.7)†	0.5 (0.4 -0.6)†
Eating fast food		
Never or only occasionally	Reference	Reference
Once or twice per week	1.2 (0.9-1.5)	1.1 (0.8-1.4)
Most or all days	1.5 (1.1-2.0)‡	1.4 (1.0-2.0)§
Consumption of soft drinks		
Never or only occasionally	Reference	Reference
Once or twice per week	1.3 (1.0-1.6)	1.2 (0.9-1.6)
Most or all days	1.4 (1.1-1.8)‡	0.9 (0.7-1.3)
Daily television time‖		
<1 h	Reference	Reference
1 to <3 h	1.0 (0.8-1.3)	0.9 (0.7-1.1)
3 to <5 h	1.2 (0.9-1.6)	1.0 (0.7-1.3)
≥5	1.4 (1.1-1.8)§	1.1 (0.8-1.5)
Trucks pass through neighborhood		
Never	Reference	Reference
Seldom	1.2 (0.9-1.6)	1.1 (0.8-1.5)
Frequently throughout the day	1.7 (1.3-2.4)‡	1.5 (1.0-2.2)§
Almost the whole day	1.6 (1.1-2.3)§	1.2 (0.8-1.9)
Paracetamol use in the past 12 months		
Never	Reference	Reference
At least once per year	1.3 (0.9-1.7)	1.2 (0.9-1.7)
At least once per month	2.5 (1.9-3.3)†	2.5 (1.8-3.5)†
Had a cat in the home in the past 12 months		
No	Reference	Reference
Yes	1.6 (1.3-2.0)†	1.6 (1.2-2.0)†
Ever used tobacco		
Not at all		
Less than daily	1.8 (1.0-3.3)	1.4 (0.7-3.0)
Daily	1.6 (0.5-4.7)	0.4 (0.1-3.5)

Adjustment was performed for all variables listed.
OR, Odds ratio.
*Wheeze during the past 12 months for all participants.
†$P < .001$.
‡$P < .01$.
§$P < .05$.
‖Including digital video recordings, films, and videos.

published literature.[31] Also, a history of pneumonia, which is due mostly to viruses in this age group, is known to be associated with an increased risk for asthma.[31] In adolescents, frequent use of paracetamol was found to be a significant risk factor, similar to the ISAAC phase 3 results.[30] This is a controversial issue; however, most studies show that there is no difference between paracetamol and ibuprofen in terms of the risk of asthma exacerbation.[32] Whether the risk is different from that with placebo is not clear. Cat ownership is also a controversial issue, and whether it increases, decreases, or has no effect on the risk of developing asthma may depend on the circumstances, such as the date of assessment and study population.[33,34]

Our study was limited by the nature of the questionnaire; "wheezing in the past 12 months" does not provide a perfect measure for asthma diagnosis, although it is the best tool available for large epidemiologic surveys. Also, the number of subjects in each country region would not allow for an assessment of asthma symptom prevalence and, subsequently, comparison of different regions and search for comparative triggers. In addition, because Saudi Arabia did not participate in ISAAC, drawing reliable time trends would be limited even with the availability of studies that have adopted the ISAAC questionnaire, because they were so variable.

In conclusion, asthma prevalence in Saudi Arabia is similar to that in many developed countries and to the international average, and it appears to be at a plateau phase. More efforts are needed to improve asthma control at the population level. Periodic studies are greatly needed to monitor asthma prevalence, severity, and control.

We would like to acknowledge every department and individual who contributed to the success of this project, including the Ministry of Education and School Health Department, the Ministry of Health, and health care workers. Also, Abdullah A. Alangari would like to thank the Deanship of Scientific Research at King Saud University in Riyadh, Saudi Arabia, for supporting him. This project took a lot of effort to conduct and would not have been possible without the support and help from them.

REFERENCES

1. Papi A, Brightling C, Pedersen SE, Reddel HK. Asthma. Lancet 2018;391:783-800.
2. Hsieh KH, Shen JJ. Prevalence of childhood asthma in Taipei, Taiwan, and other Asian Pacific countries. J Asthma 1988;25:73-82.
3. Burr ML, Butland BK, King S, Vaughan-Williams E. Changes in asthma prevalence: two surveys 15 years apart. Arch Dis Child 1989;64:1452-6.
4. Weitzman M, Gortmaker SL, Sobol AM, Perrin JM. Recent trends in the prevalence and severity of childhood asthma. JAMA 1992;268:2673-7.
5. Anderson HR, Butland BK, Strachan DP. Trends in prevalence and severity of childhood asthma. BMJ 1994;308:1600-4.
6. ECRHS) TECRHS. Variations in the prevalence of respiratory symptoms, self-reported asthma attacks, and use of asthma medication in the European Community Respiratory Health Survey (ECRHS). Eur Respir J 1996;9:687-95.
7. Reijula J, Latvala J, Mäkelä M, Siitonen S, Saario M, Haahtela T. Long-term trends of asthma, allergic rhinitis and atopic eczema in young Finnish men: a retrospective analysis, 1926-2017. Eur Respir J 2020;56:1902144.
8. 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.
9. Ellwood P, Asher MI, Billo NE, Bissell K, Chiang CY, Ellwood EM, et al. The Global Asthma Network rationale and methods for phase I global surveillance: prevalence, severity, management and risk factors. Eur Respir J 2017;49:1601605.
10. Asher MI, Garcia-Marcos L, Pearce NE, Strachan DP. Trends in worldwide asthma prevalence. Eur Respir J 2020;56:2002094.
11. Shaw R, Woodman K, Ayson M, Dibdin S, Winkelmann R, Crane J, et al. Measuring the prevalence of bronchial hyper-responsiveness in children. Int J Epidemiol 1995;24:597-602.
12. Stewart AW, Asher MI, Clayton TO, Crane J, D'Souza W, Ellwood PE, et al. The effect of season-of-response to ISAAC questions about asthma, rhinitis and eczema in children. Int J Epidemiol 1997;26:126-36.
13. Committee TISoAaAiCIS. 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.
14. Asher MI, Montefort S, Björkstén B, Lai CK, Strachan DP, Weiland SK, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC phases one and three repeat multicountry cross-sectional surveys. Lancet 2006;368:733-43.
15. Pearce N, Aït-Khaled N, Beasley R, Mallol J, Keil U, Mitchell E, et al. Worldwide trends in the prevalence of asthma symptoms: phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax 2007;62:758-66.
16. García-Marcos L, Asher MI, Pearce N, Ellwood E, Bissell K, Chiang CY, et al. The burden of asthma, hay fever and eczema in children in 25 countries: GAN Phase I study. Eur Respir J 2022;60:2102866. https://doi.org/10.1183/13993003.02866-2021.
17. Ducharme FM, Tse SM, Chauhan B. Diagnosis, management, and prognosis of preschool wheeze. Lancet 2014;383:1593-604.
18. Al-Moamary MS, Alhaider SA, Alangari AA, Idrees MM, Zeitouni MO, Al Ghobain MO, et al. The Saudi Initiative for Asthma - 2021 update: guidelines for the diagnosis and management of asthma in adults and children. Ann Thorac Med 2021;16:4-56.
19. de Marco R, Locatelli F, Sunyer J, Burney P. Differences in incidence of reported asthma related to age in men and women. A retrospective analysis of the data of the European Respiratory Health Survey. Am J Respir Crit Care Med 2000;162:68-74.
20. Akinbami LJ, Moorman JE, Garbe PL, Sondik EJ. Status of childhood asthma in the United States, 1980-2007. Pediatrics 2009;123(suppl 3):S131-45.
21. Alomary SA, Al Madani AJ, Althagafi WA, Adam IF, Elsherif OE, Al-Abdullaah AA, et al. Prevalence of asthma symptoms and associated risk factors among adults in Saudi Arabia: a national survey from Global Asthma Network phase I. World Allergy Organ J 2022;15:100623.
22. Del-Rio-Navarro BE, Berber A, Reyes-Noriega N, Navarrete-Rodriguez EM, Garcia-Almaraz R, Ellwood P, et al. Global Asthma Network phase I study in Mexico: prevalence of asthma symptoms, risk factors and altitude associations—a cross-sectional study. BMJ Open Respir Res 2020;7:e000658.
23. Chinratanapisit S, Suratannon N, Pacharn P, Sritipsukho P, Vichyanond P. Prevalence and severity of asthma, rhinoconjunctivitis and eczema in children from the Bangkok area: the Global Asthma Network (GAN) phase I. Asian Pac J Allergy Immunol 2019;37:226-31.
24. Marin-Cassinello A, Vega- Hernández MC, Lumbreras-Lacarra B, De Arriba-Méndez S, Pellegrini- Belinchón J. Prevalence of symptoms, severity and diagnosis of asthma in adolescents in the Province of Salamanca, Spain: Global Asthma Network (GAN) phase I. Allergol Immunopathol (Madr) 2021;49:106-12.
25. Al Frayh AR, Shakoor Z, Gad El Rab MO, Hasnain SM. Increased prevalence of asthma in Saudi Arabia. Ann Allergy Asthma Immunol 2001;86:292-6.
26. Sobki SH, Zakzouk SM. Point prevalence of allergic rhinitis among Saudi children. Rhinology 2004;42:137-40.
27. Al Ghobain MO, Al-Hajjaj MS, Al Moamary MS. Asthma prevalence among 16- to 18-year-old adolescents in Saudi Arabia using the ISAAC questionnaire. BMC Public Health 2012;12:239.
28. Nahhas M, Bhopal R, Anandan C, Elton R, Sheikh A. Prevalence of allergic disorders among primary school-aged children in Madinah, Saudi Arabia: two-stage cross-sectional survey. PLoS One 2012;7:e36848.
29. Mohamed Hussain S, Ayesha Farhana S, Mohammed Alnasser S. Time trends and regional variation in prevalence of asthma and associated factors in Saudi Arabia: a systematic review and meta-analysis. Biomed Res Int 2018;2018:8102527.
30. Silverwood RJ, Rutter CE, Mitchell EA, Asher MI, Garcia-Marcos L, Strachan DP, et al. Are environmental risk factors for current wheeze in the International Study of Asthma and Allergies in Childhood (ISAAC) phase three due to reverse causation? Clin Exp Allergy 2019;49:430-41.
31. Castro-Rodriguez JA, Forno E, Rodriguez-Martinez CE, Celedón JC. Risk and protective factors for childhood asthma: what is the evidence? J Allergy Clin Immunol Pract 2016;4:1111-22.
32. Sherbash M, Furuya-Kanamori L, Nader JD, Thalib L. Risk of wheezing and asthma exacerbation in children treated with paracetamol versus ibuprofen: a systematic review and meta-analysis of randomised controlled trials. BMC Pulm Med 2020;20:72.
33. Ihuoma H, Belgrave DC, Murray CS, Foden P, Simpson A, Custovic A. Cat ownership, cat allergen exposure, and trajectories of sensitization and asthma throughout childhood. J Allergy Clin Immunol 2018;141:820-2.e7.
34. de Moira AP, Strandberg-Larsen K, Bishop T, Pedersen M, Avraam D, Cadman T, et al. Associations of early-life pet ownership with asthma and allergic sensitization: a meta-analysis of >77,000 children from the EU Child Cohort Network. J Allergy Clin Immunol 2022;150:82-92.