
Changes in asthma prevalence and impact on health and function in Seattle middle-school children: 1995 vs 2003

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Background: The prevalence of asthma has increased during the past several decades but may have stabilized during the last 5 years. It is not known whether the functional and health impact of asthma has decreased during the past decade.

Objective: To evaluate changes during a recent 8-year period in the prevalence and health and functional impact of current asthma symptoms in young teenagers.

Methods: In 1995 and 2003, 2,330 and 2,397 middle-school students from Seattle, WA, respectively (median age, 13 years), completed written surveys and answered questions pertaining to 4 wheezing or asthma video scenarios. Children were categorized as having physician-diagnosed current asthma (wheeze in the past year *and* a physician diagnosis of asthma), undiagnosed current asthma symptoms (wheeze in the past year *without* a physician diagnosis), or no asthma. Outcome measures were the prevalence of asthma and undiagnosed asthma symptoms and the differences between years in respiratory-associated functional impairment (exercise limitation, missed school, disrupted sleep) and health impact (physician visits, wheeze-limited speech).

Results: The prevalence of physician-diagnosed current asthma increased from 1995 to 2003 (3.0% to 6.2%), whereas that for undiagnosed current asthma symptoms decreased (12.0% to 6.2%). The degree of functional and health impairment was similar between the 2 study periods for each subgroup and was highest in the children with physician-diagnosed current asthma.

Conclusions: The prevalence of current asthma symptoms in middle-school children from Seattle decreased slightly between 1995 and 2003, whereas the diagnosis of asthma increased. However, the health and functional impact of asthma did not diminish. Asthma is being diagnosed more often, but many children with asthma are still not achieving good asthma control.

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INTRODUCTION

Asthma is one of the most common chronic disorders of childhood, and its economic, functional, and health impacts are substantial.^{1–3} The prevalence of asthma increased during the past several decades,^{4–7} but data from several countries suggest that since the mid-1990s asthma prevalence has stabilized.^{8–11} In the United States, during the past decade hospitalization rates and deaths among children with asthma have decreased, whereas outpatient visits for asthma have increased.^{1,4} This finding suggests that more children are seeking care earlier for asthma and avoiding severe morbidity. However, little information is available to determine whether these favorable trends in prevalence and morbidity are associated with decreased functional impairment (eg, exercise limitation, missed school, and sleep disturbance) in children with asthma.

Recently, Yeatts et al^{12–14} reported on the health impact of asthma and undiagnosed asthma symptoms in a large cohort of young teenaged children. Using a video questionnaire adapted from the International Study of Allergies and Asthma in Childhood (ISAAC),¹⁵ they queried more than 120,000 students, 12 to 14 years old, on asthma diagnosis and asthma-like symptoms. They noted that both children with diagnosed asthma and those with undiagnosed asthma symptoms reported more unscheduled physician visits, hospitalizations, and missed school days due to respiratory problems than did children without asthma symptoms. In addition, a disproportionate number of students who met criteria for current asthma symptoms had exercise intolerance and sleep disturbance. They also found that a significant number of children with current asthma symptoms had undiagnosed conditions, and these patients with undiagnosed asthma were at significant risk of functional and health impairment. Thus, although asthma prevalence and severe morbidity may be decreasing, we do not know whether the overall impact of asthma on the health and function of children is truly abating.

We sought to determine changes in the prevalence of asthma diagnosis and symptoms and also whether the health impairment and functional impact from asthma decreased during the past decade. Our group participated in both phase 1 (in 1995) and phase 3 (in 2003) of ISAAC. These large multinational studies were designed to evaluate the preva-

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lence of asthma symptoms in children across the world. During phase 1, approximately 300,000 children 13 to 14 years old from 42 countries completed a series of written questions and a video survey.^{15,16} Phase 3 was performed between 2000 and 2003. We added questions concerning physician diagnosis, health impairment, and functional impact of asthma to both ISAAC surveys, and this enabled us to use the same questions and preset criteria for asthma diagnosis for both study years. Our objectives were to determine differences in the prevalence of asthma and asthma symptoms between the years 1995 and 2003 and to evaluate whether the functional impact and health impairment of asthma had diminished.

METHODS

Subjects

In February and March 1995 and June 2003 we asked middle-school students from Seattle, WA, to complete a written and video questionnaire as part of the ISAAC study (phase 1 in 1995 and phase 3 in 2003). The Seattle School Board approved the protocols, and in each year, 6 of 10 eligible schools agreed to participate. The University of Washington Human Subjects Committee approved the protocol and

granted a waiver of written informed consent. We provided detailed written information to parents and both verbal and written information to the students and gave them ample time to refuse participation. We targeted 13- to 14-year-old children, primarily in the seventh and eighth grades, but sixth grade students were also eligible. Investigators distributed the questionnaires and oversaw completion of the questionnaires during typical class periods. In 1995 2,330 (80%) of 2,900 and in 2003 2,397 (86%) of 2,797 of the eligible students in the participating schools completed the video and written portions of the questionnaire. School absenteeism accounted for most students who did not complete the survey. The median age of the students for both study periods was 13 years (Table 1).

Study Questionnaire and Administration

The written questionnaire contained 26 core ISAAC questions on asthma, allergies, and eczema. We added the same questions to both the 1995 and 2003 surveys on physician diagnosis of asthma and the functional impairment (exercise limitation, missed school days, sleep disturbance) and health impact (physician visits, wheeze-limited speech) due to respiratory problems. Before each testing period, a member of

Table 1. Patient Demographics for the 1995 and 2003 Study Periods

Demographics	All patients	Physician-diagnosed current asthma	Undiagnosed current asthma symptoms	No current asthma
No. of patients				
1995	2,330	70	279	1,393
2003	2,397	148	148	1,510
Age, median (range), y				
1995	13 (12–16)	13 (12–15)	14 (12–16)	13 (12–16)
2003	13 (10–16)	13 (12–15)	14 (11–15)	13 (10–16)
Males, %				
1995	47	41	41	49
2003	48	47	35	50
White, %				
1995	38*	17	42	39*
2003	31	27	35	31
African American, %				
1995	20	44	23	17
2003	21	33	23	17
Asian, %				
1995	19*	16	14	20*
2003	32	18	23	35
Native America, %				
1995	2	0	2	2
2003	2	3	7	2
Other, %				
1995	21*	23	19	22*
2003	14	19	12	15
Hispanic, %				
1995	19*	19	21	18*
2003	8	24	14	11

* These values for 1995 vs 2003 were statistically significantly different ($P < .001$, χ^2). There were no statistically significant differences in the racial compositions of the asthma groups.

the study team explained to the students that participation was completely voluntary and made sure that students knew they were not required to complete the questionnaire. In addition to the written questions, students viewed the international version of the ISAAC video, which has 1 coughing and 4 wheezing scenarios that depict children with asthma. The same video was used for both study years.

Definitions of the Study Groups

We wished to identify children who had asthma symptoms within the past 12 months (eg, current asthma symptoms), and we classified children into the following groups based on their responses to the written and video portions of the survey.

Physician-diagnosed current asthma. This group contained students who answered yes to the written questions, "Have you had wheezing or whistling in your chest in the past 12 months?" and "Has a doctor ever told you that you have asthma?" plus yes in the past year to any of the 4 video wheezing scenarios. We did not use the responses to the cough video scenario.

Undiagnosed current asthma symptoms. This group contained students who answered yes to the written question, "Have you had wheezing or whistling in your chest in the past 12 months?" and yes in the past year to any of the 4 video wheezing scenarios but answered no to the question, "Has a doctor ever told you that you have asthma?"

No current asthma. This group contained students who answered no to wheezing in the past year, no to physician diagnosis, and no in the past year to all 4 of the video wheezing scenarios.

Students who did not fit into any of these 3 groups were not included in the analysis.

We measured functional impact using responses to questions concerning exercise limitation and missed school days within the past 12 months due to "wheezing, dry cough, and/or breathing problems" and also by sleep disturbance "due to wheezing within the past 12 months." We evaluated health impairment with responses to questions on physician visits during the past 12 months for "wheezing, dry cough, and/or breathing problems" and any episodes within the past 12 months of "wheezing severe enough to limit speech to one or two words at a time."

Outcome Measures and Statistical Analysis

The outcome measures were (1) changes in both the prevalence of physician-diagnosed current asthma and undiagnosed current asthma symptoms between the years 1995 and 2003; (2) differences in functional impact and health impairment among the physician-diagnosed current asthma, undiagnosed current asthma symptoms, and the no current asthma groups; and (3) changes in functional impact and health impairment due to asthma between 1995 and 2003. We computed 95% confidence intervals for each variable and used χ^2 analysis to analyze differences among groups both within and between study years.

RESULTS

In 1995 and 2003, 2,330 and 2,397 middle-school students, respectively, completed the survey. More students were of Asian heritage and fewer were white in 2003 than in 1995 ($P < .001$), but there were similar proportions of African American students (Table 1). No statistically significant differences occurred in the racial compositions of the physician-diagnosed current asthma and undiagnosed current asthma symptoms groups between 1995 and 2003. In both years, approximately 25% of the respondents (588 in 1995 and 591 in 2003) did not meet criteria for any of the 3 groups, and they were not included in further analysis.

The prevalence of respondents with current asthma symptoms (physician-diagnosed group and undiagnosed current asthma group) was slightly higher in 1995 than in 2003 (15.0% vs 12.4%, $P = .01$), and this remained true after adjusting for differences in the racial compositions of the groups (14.7% vs 13.0%, $P = .01$). However, the percentage of respondents with current asthma symptoms and a physician diagnosis doubled from 1995 to 2003, whereas the proportion with current asthma symptoms but no physician diagnosis significantly decreased (Table 2). In 1995, only 1 of 5 respondents with current asthma symptoms had a physician diagnosis compared with 1 of 2 in 2003.

In both 1995 and 2003, children with physician-diagnosed current asthma had more functional impairment than those with undiagnosed current asthma symptoms (Table 2). In both years, more than half of the children with physician-diagnosed current asthma reported some exercise intolerance, missed school due to respiratory problems, and sleep disrupted by wheezing compared with approximately one third of the children with undiagnosed current asthma symptoms and less than 11% of those without asthma symptoms (Table 2).

In both 1995 and 2003, children with current asthma symptoms had significantly more health impairment than did children without asthma. In both years, significantly more children with physician-diagnosed current asthma sought medical attention for respiratory problems and reported wheeze-limited speech than did those with undiagnosed current asthma symptoms, whereas the no current asthma group had the fewest physician visits and episodes of wheeze-limited speech (Table 2). The proportion of children with asthma symptoms who visited a physician in the past year for respiratory problems decreased from 1995 to 2003, although this proportion continued to be high. No change occurred between 1995 and 2003 in the proportion of children with either physician-diagnosed or undiagnosed current asthma symptoms who reported wheeze-limited speech. Inhaler use among children with physician-diagnosed current asthma increased between 1995 and 2003, whereas it decreased in children with undiagnosed current asthma symptoms. However, even in 2003 more than 20% of children with current asthma symptoms but no physician diagnosis reported using an inhaled medication within the last year.

Table 2. Asthma Prevalence, Functional Impairment, and Health Impact for the 1995 and 2003 Study Periods*

Variable	Physician-diagnosed current asthma	Undiagnosed current asthma symptoms	No current asthma
No. of patients			
1995	70	279	1,393
2003	148	148	1,510
Prevalence, % (95% CI)			
1995	3.0 (2.2–3.7)	12.0 (10.6–13.4)	59.8 (57.8–61.8)
2003	6.2 (5.2–7.2)	6.2 (5.2–7.2)	64.0 (61.6–66.3)
Patients with exercise limitations, % (95% CI)			
1995	74 (64–84)	31 (25–36)	4 (3–5)
2003	74 (67–81)	62 (54–69)	10 (8–11)
Patients with missed school days, % (95% CI)			
1995	69 (58–79)	29 (23–34)	8 (6–9)
2003	52 (44–60)	33 (26–41)	11 (9–13)
Patients with disrupted sleep, % (95% CI)			
1995	67 (56–78)	34 (29–40)	0 (0–0)
2003	53 (45–61)	38 (30–46)	1 (0–2)
Patients with physician visits (≥ 1 in last year), % (95% CI)			
1995	90 (83–97)	50 (44–56)	11 (9–13)
2003	74 (67–81)	41 (34–49)	11 (9–13)
Patients with wheeze-limited speech, % (95% CI)			
1995	56 (44–67)	33 (28–39)	0.0 (0–0)
2003	50 (42–58)	33 (26–41)	0.3 (0–0)
Patients with inhaler use in past year, % (95% CI)			
1995	74 (64–85)	45 (39–51)	2 (1–3)
2003	88 (82–93)	22 (15–29)	2 (2–3)

Abbreviation: CI, confidence interval.

*Prevalence values are expressed as percentage of the total number of respondents ($n = 2,330$ in 1995 and 2,397 in 2003). All other values are the percentage of patients in each subgroup with the outcome.

DISCUSSION

We found that the prevalence of current asthma symptoms in middle-school children from Seattle decreased slightly between 1995 and 2003, whereas the proportion of children actually diagnosed as having asthma doubled. Yet, despite the increase in diagnosis, half of the children with current asthma symptoms in 2003 had not had their conditions diagnosed. In addition, the functional impact and health impairment from asthma remained high and remarkably similar during this 8-year period. Children with diagnosed asthma continued to have more functional and health impairment than those with undiagnosed current asthma symptoms.

Our results in children from the United States agree with those from other countries and support the contention that the prevalence of asthma in children has remained stable during the past 5 to 10 years. Similar studies based on responses to questionnaires or information obtained from health databases have demonstrated a leveling off of asthma prevalence in the 1990s in Italy,⁸ Canada,⁹ Switzerland,¹⁰ and Turkey.¹¹ Akinbami and Shoendorf,⁴ using data from the US National Health Interview Survey, found no difference in the asthma attack rates in children for the years 1997 through 2000, but changes in the criteria used to measure asthma prevented comparison with earlier years. However, Maziak et al¹⁷ noted an increase in asthma symptoms between 1995 and 2000 in German

school-aged children. No clear explanation exists for the stabilization of asthma prevalence during the past decade. One interesting hypothesis, proposed by Nowak et al,¹⁸ is that only a certain percentage of the population is at risk for asthma and that we are reaching the saturation point for that susceptible population; once all susceptible persons develop the disease, then the prevalence will not change.

Similar to the study by Yeatts et al,¹³ we found that the children with current asthma symptoms had significantly more exercise limitation, sleep disturbance, and physician visits due to acute respiratory problems than did those without asthma. In both studies, more than 50% of children with diagnosed asthma reported respiratory-related health and functional impairment compared with approximately one third of those with undiagnosed asthma symptoms. In our study, children with current asthma symptoms had far more respiratory-related functional and health impairment than the approximately 60% of the study population without asthma symptoms. This is consistent with reports by other investigators that asthma continues to be a major social, economic, and health burden.^{1–3}

Despite the increase in asthma diagnosis between 1995 and 2003, little change occurred in the health impairment and functional impact from asthma. In both study years, many children with current asthma symptoms reported exercise

limitation, missed school days, sleep disturbance, speech limited by wheeze, and physician visits for respiratory complaints. Thus, although asthma is being diagnosed more often, many children with asthma are still not achieving good asthma control. Children with undiagnosed current asthma symptoms reported less functional limitation and health impairment than those with a physician diagnosis. This “undiagnosed group” may represent children with less severe asthma, which in turn may explain why they were less likely to have their conditions diagnosed.

Our findings of increased physician diagnosis of asthma but no improvement in health impact or functional impairment occurred during a time when national guidelines for diagnosis and treatment of asthma and new asthma therapies had emerged. In 1991, the National Heart, Lung, and Blood Institute (NHLBI) published an extensive asthma guideline,¹⁹ which was fully revised and reimplemented in 1997²⁰ and then updated in 2002.²¹ The Global Initiative for Asthma, in conjunction with the NHLBI, has published a similar guideline on their Web site since 2002.²² In addition, during the past decade the use of leukotriene receptor antagonists, long-acting β_2 -agonists, and devices that deliver combinations of controller agents has increased. Our data suggest that efforts to educate health care clinicians and the public have increased the awareness and diagnosis of asthma but that this has not translated into clinical benefit. Thus, despite knowing of these treatment guidelines, clinicians and patients are not necessarily following them. Flores et al²³ reported that 88% of pediatricians surveyed in the United States were aware of asthma guidelines and that 77% used them to some extent. Yet, many patients with asthma still do not receive treatment consistent with the guidelines,^{24,25} and even if they receive appropriate therapy, their adherence to it is often poor.^{26,27}

One of the main difficulties in comparing asthma prevalence between different years and different studies is the variation in methods and criteria used to define asthma and asthma symptoms. The ISAAC questionnaire has been used widely, and both the written and video portions have been validated as tools to measure the prevalence of asthma symptoms in children.^{28,29} Several of the questionnaire-based studies used adapted ISAAC surveys,^{10,12–14,17} whereas others accessed large national databases to determine asthma prevalence and health burden.^{4,9} We opted to define current asthma symptoms by a positive response to both a written question and to at least 1 of the 4 video asthma and wheezing scenarios. Although fair agreement exists between responses to the core ISAAC written and video asthma questions, there are children who will respond positively to one and not the other.³⁰ Thus, we reasoned that requiring positive responses to both a written and video question would be more specific, albeit less sensitive, for current asthma symptoms.

There are several important limitations to our study. The results are based on the responses of young teenagers, who may not have reported their symptoms accurately or known that a physician had diagnosed them as having asthma. The

children all attended Seattle public schools, and results from this population may not be representative of other groups of children. Of note, our study included a significant number of Asian children, and few data are available from the United States on asthma prevalence and morbidity in this important group. Our criteria for physician-diagnosed current asthma and undiagnosed current asthma symptoms were arbitrary, although similar to those from previous studies. We attempted to correct for these limitations by using the same patient population, diagnostic criteria, and survey tool for both study years. Another limitation is that we did not quantify respiratory-related functional or health consequences. Thus, although we could determine changes in the proportion of children who reported impairment, we were not able to evaluate the degree of impairment. Finally, it is likely that some of the children who met our criteria for current asthma symptoms did not have asthma, whereas others who truly had asthma were not included. The ISAAC video and written questions have been shown to have high specificity with regard to clinical asthma, but their sensitivity is lower. The video questions have a higher specificity but a lower sensitivity than the written questions. Fuso et al²⁸ reported the specificity of each of the video questions to be more than 0.9 with a sensitivity of less than 0.4, and the sensitivity of the written questions ranged from 0.44 to 0.75. Therefore, it is likely that our combination of written and video questions was specific but not particularly sensitive for identifying students with asthma. Approximately 25% of the students did not meet our criteria for either current asthma symptoms or no asthma, and some of these children surely had asthma. However, our criteria likely resulted in a high specificity, and the widespread use of inhaled medications in students who reported current asthma symptoms suggests that many of these children truly had asthma.

In conclusion, we found that the prevalence of current asthma symptoms in middle-school students from Seattle decreased slightly between 1995 and 2003, whereas the proportion of children who reported a physician diagnosis of asthma increased. Yet, even with this increase in physician diagnosis, half of the children with current asthma symptoms in 2003 had not had their conditions diagnosed. In addition, the health impairment and functional impact from asthma are still high and have not significantly abated during the past decade. Children with current asthma symptoms, both with and without a physician diagnosis, experience significantly more functional limitation and health consequences than those without evidence of asthma. We need to improve our diagnosis and management of asthma and continue to explore means of decreasing the burden of this disease.

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