Assessment of Respiratory Symptoms and Asthma Prevalence in a U.S.–Mexico Border Region

GEORGE A. STEPHEN
Southern Arizona VA Health Care System
University of Arizona
Tucson, Arizona
CHERYL McRILL
Health Sciences Center
University of Arizona
Tucson, Arizona
MAURA D. MACK
Arizona Department of Health Services
Phoenix, Arizona
MARY KAY O'ROURKE
Health Sciences Center
University of Arizona
Tucson, Arizona
TIMOTHY J. FLOOD
Arizona Department of Health Services
Phoenix, Arizona
MICHAEL D. LEBOWITZ
Health Sciences Center
University of Arizona
Tucson, Arizona

ABSTRACT. The authors studied children who were 10–12 yr of age and who resided in sister cities in a U.S.–Mexico border region to determine the prevalence of asthma and respiratory symptoms. The relationship of symptoms to ambient levels of particulate matter less than 10 µm in diameter (PM_{10}), and to several indoor environmental conditions, was assessed. The study was conducted in the border cities of Ambos Nogales (Nogales, Arizona [United States], and Nogales, Sonora [Mexico]). At the beginning of the 11-wk study, during the autumn of 1996, 631 students and their parents completed baseline questionnaires. While in school, the children completed daily symptom diaries and daily peak expiratory flow maneuvers. PM_{10} values and daily temperatures were also measured. The authors found that the prevalence of self-reported asthma among 5th-grade students was comparable on both sides of the border (i.e., 7.6% on the Arizona side and 6.9% on the Sonora side). Wheezing was a frequent complaint (29.5–35.6%), as was cough (16.8–29.6%). Smoking in the home was common on both sides of the border, and it was associated with a greater occurrence of self-reported asthma and respiratory complaints. Increased respiratory symptoms were also associated with increased ambient PM_{10} levels. The prevalence of respiratory symptoms such as wheezing and frequent cough among all children in this study, combined with the limitations inherent in self-reporting, suggest that asthma may actually be more prevalent than has been previously reported.
<Key words: air pollution, asthma, Hispanic, smoking, wheezing>

ASTHMA is currently 1 of the most prevalent chronic diseases affecting children in the United States. Reported asthma prevalence worldwide varies widely—from less than 5% to more than 20%—depending on the definition and method used, and the population studied.[1–7] Currently, substantial evidence exists that asthma prevalence is increasing in industrialized societies—especially among children and minorities. Asthma, as is the case with many other health conditions, apparently exerts its greatest impact on minorities, especially residents of inner-city areas.[8–14]

The National Health and Nutrition Examination Survey (NHANES) in the United States has found asthma prevalence rates that linger between 4% and 6.7% in entire populations.[15] NHANES data, from the U.S. National Center for Health Statistics, showed an increase in asthma prevalence in 6–11 yr olds—from 4.7% in 1971–1974 to 7.6% in 1976–1980 (*asthma* was defined as "wheezing within the past 12 mo" or by a diagnosis of asthma indicated by a physician[16]). Preliminary NHANES III data revealed the presence of prevalence rates slightly greater than 10% (i.e., 10 yr later).[17]

In a 1990 study of predominately Hispanic inner-city 9–12 yr olds in San Diego, the authors noted a 14.4%

probable current asthma prevalence as determined on the basis of symptoms of wheezing or physician-diagnosed asthma.[18] A prevalence rate of 15.8% was found in 3–5-yr–old children in a non-inner-city Head Start program in Dade County, Wisconsin.[19] In 1994, an additional study in Chicago of predominately African-American children who were 10–11 yr of age showed that 34.5% of children reported ever wheezing, 28.9% reported wheezing in the past year, and 23.6% reported physician-diagnosed asthma.[20] A study in Oregon in 1995 found a current asthma prevalence of 6–7%, and a lifetime prevalence of 6–11% was determined for both Anglo children and adults.[21] A report from Bogalusa, Louisiana, showed an increase in asthma prevalence from 9.2% in 1983–1985 to 15.9% in 1992–1994.[22] In a 1995 study in Nottingham, England, (a) "wheezing ever" was reported in 24% of children, (b) wheezing during the past year in 15.1%, and (c) symptomatic asthma was diagnosed in the past year in 8.8% of children.[23] Other recent studies have contained variable rates in children worldwide.[24–28]

Identifying asthma cases for epidemiological studies is problematic because there is a lack of consensus regarding the definitions used. Also, for several reasons, a significant amount of asthma may be underdiagnosed.[29,30] Reported increases in the prevalence, severity, and mortality of asthma have heightened awareness of these health problems.

Earlier, the current prevalence of asthma on the Arizona-Mexico border was uncertain, as was the air pollution burden. At public meetings held in 1993, the residents of Nogales, Arizona, expressed many concerns about air quality in their city and how it might affect health; asthma was a disease of *major* local concern. Health workers at public schools were particularly worried about a perceived excess of respiratory disease and asthma among students, but statistics on the current prevalence of childhood asthma in the region were lacking. In addition, it was widely speculated that the North American Free Trade Agreement would lead to accelerated industrial development in border towns, such as Nogales. Increased vehicular traffic and population growth—which would place even more environmental stress on the region—were also predicted. The respiratory effects of air pollution are well known, especially in individuals with chronic lung diseases.[31–35]

In response to the aforementioned concerns, a collaborative bi-national study was designed by the Arizona Department of Health Services, the Arizona Department of Environmental Quality, the University of Arizona Health Sciences Center, the Nogales School Districts, and the Secretaría de Salud Pública de Sonora. In this study, we sought to (a) document cross-sectionally the level of respiratory symptoms, including asthma, in the region and provide a reference point for the future as the towns increase in size and population, and consequently develop industrially; (b) determine cross-sectionally whether asthma prevalence rates are elevated in the region, compared with other populations; and (c) determine the relationship, if any, between daily prevalence rates of symptoms and ambient levels of particulate matter less than 10 μm in diameter (PM_{10}). (The effect[s] of these daily ambient conditions on daily symptoms and peak flow will be examined in another paper, because complexity exists in the time-series analyses).

Materials and Method

The cumulative prevalence of asthma was determined cross-sectionally at the beginning of the study. This 11-wk study occurred in the autumn of 1996 (i.e., during the school semester), a time when air pollution in this region tends to be higher and more variable than during other seasons.

The proposed study was approved by the school superintendents, the school board, school nurses, principals, and teachers. In addition, approval for the study protocol was obtained from the Secretaría de Salud Pública de Sonora, and from the Arizona Department of Health Services and the University of Arizona Institutional Review Board Human Subjects Review committees.

Study population. Our study was conducted in the U.S.–Mexico border cities of Nogales, Arizona, in the United States; and Nogales, Sonora, in Mexico. The population of Nogales, Sonora, is about 10 times that of Nogales, Arizona, where in 1996 the population was 20,765. Currently, the only physical separation between the towns is a steel fence. Locally, the 2 towns are known as Ambos Nogales (Spanish for "both Nogales").

Fifth-grade students (10–12 yr of age) served as the study population because they were sufficiently mature to understand the purpose of the study, were generally able to follow instructions, and, in this region, rarely smoked. All elementary schools in Nogales, Arizona, were asked to participate; in Nogales, Sonora, elementary schools were chosen on a geographically representative basis.

Three of the 5 public schools in the Arizona area agreed to ask their classes to participate in the study. The remaining 2 schools declined to participate, citing competing demands on their time; however, their lack of participation did not affect the desired site distribution. All of the Sonoran schools agreed to participate. Of the 393 students eligible for participation from the 3 schools on the Arizona side, 328 (83.4%) had parental consent, and they completed a student questionnaire. Of the 315 students eligible for participation from 4 schools selected on the Sonora side, 303 (96.1%) completed a student questionnaire.

Forms and questionnaires. English and Spanish versions of all forms and questionnaires were used; Span-

ish terms and phrases appropriate to each border region were used. Questionnaires were translated into Spanish by medical personnel familiar with local idioms; they were then back-translated into English to verify the content of each question and to minimize the chance of misinterpretation caused by language differences. Parents and teachers in Arizona could choose which version they preferred. Item analyses were performed on each version, and the results were compared. Specific data on ethnicity were not obtained because the schools estimated that more than 85% of the Arizona students, and essentially all of the Sonoran students, were Hispanic. Most Nogales, Arizona, children and parents are bilingual. On the Arizona side of the border, 60% of parents and 80% of children preferred the English language questionnaire.

Data collection. Information for the study originated from several sources:

- Initially, we sent an explanatory letter to parents asking for their consent for their child to participate in the study. Written informed consent (parent's and child's) was obtained for each participating child. Parents then completed a questionnaire about the home environment, including the age of the home, type of heating and cooling used, products used in the home, and their child's health history.
- Each child in the study completed a baseline questionnaire. In it, he or she reported respiratory symptoms, various aspects of the home environment (e.g., presence of smokers, number of persons sleeping in their room), and medical history.
- Every morning at school, the child recorded in a diary any respiratory symptoms—such as cough, wheeze, or runny nose—experienced during the preceding 24 hr or the preceding weekend.
- At the start of the study, a trained nurse or other school health professional instructed each child in the use of a MiniWright Peak Flow Meter (Clement Clarke Ltd. [Essex, Great Britain]). School health workers and study investigators reinforced this instruction during the course of the study. Under teacher supervision, each child performed a peak flow maneuver each morning, and usually again before leaving school, and the results were recorded in their diary.
- Ambient PM_{10} and $PM_{2.5}$ were measured (in micrograms of particles per cubic meter of air) with dichotomous Harvard impactors (Air Diagnostics and Engineering, Inc. [Harrison, Maine]), for a 24-hr period at each site, on alternate days. PM levels for nonsampled days were interpolated, using data from the previous and following days. PM samples were collected from 4 sites in the 2 towns near the city center (2 in each city).

Health workers and investigators checked the questionnaires, devices, and peak flow performances. Air pollution on both sides of the border was monitored by the Arizona Department of Environmental Quality, and additional University of Arizona monitors were used along the border on the Arizona side.

Data entry and analysis. Each student in the study was assigned a unique identification number, which was used on all of their forms and on their parent's questionnaire. Data from each participant's form were entered on customized data entry screens created with Clipper software, and it was recorded in a database. Data from the questionnaires and diaries were entered 2 separate times, and the databases were then searched for discrepant entries, which were resolved by reviewing the original data form.

In addition to using the self-reported answers about current and past physician-confirmed asthma, the respiratory status of the students was classified on the basis of their responses on the student's questionnaire. The 4 categories of symptoms are shown in the Table 1.

Data were analyzed using the SPSS (SPSS, Inc. [Chicago, Illinois]) and STATA (STATA Corp. [College Station, Texas]) statistical packages. For all analyses, p values < 0.05 were regarded as statistically significant. Study group comparisons were achieved with χ^2, Student's t test, analysis of variance, and regression analysis, as appropriate.

Results

Baseline questionnaire. Of the Ambos Nogales students, 55.8% were male and 44.2% were female. On the basis of the respiratory categories given in Table 1, the proportion of students with current asthma (Category 1) was 7.6% on the Arizona side and 6.9% on the Sonora side. The percentage with moderate to severe respiratory symptoms, but not definite current asthma (Category 2), was 17% in Arizona and 17% in Sonora. Students classified with mild respiratory symptoms (Category 3) comprised 23.5% in Arizona and 14.2% in Sonora. The proportion with minimal or no symptoms (Category 4) was 51.8% in Arizona and 61.7% in Sonora.

Further tabulation of the student's baseline questionnaires revealed the following findings. A total of 29.6% of Arizona students noted a "frequent cough" during the previous 3 mo; the percentage was significantly lower (16.8%) in Sonora. Reported wheezing complaints were experienced by 35.6% of students in Arizona and 29.5% in Sonora. Hay fever prevalence rates were significantly different, with 22.5% reporting hay fever in Arizona and 7.6% in Sonora (Table 2).

The prevalence rates for asthma and respiratory prevalence rates obtained from the baseline questionnaires were not linked significantly to gender, use of pesticides, presence of pets, or use of air conditioning or

Table 1.—Categorization of Students' Respiratory Symptoms

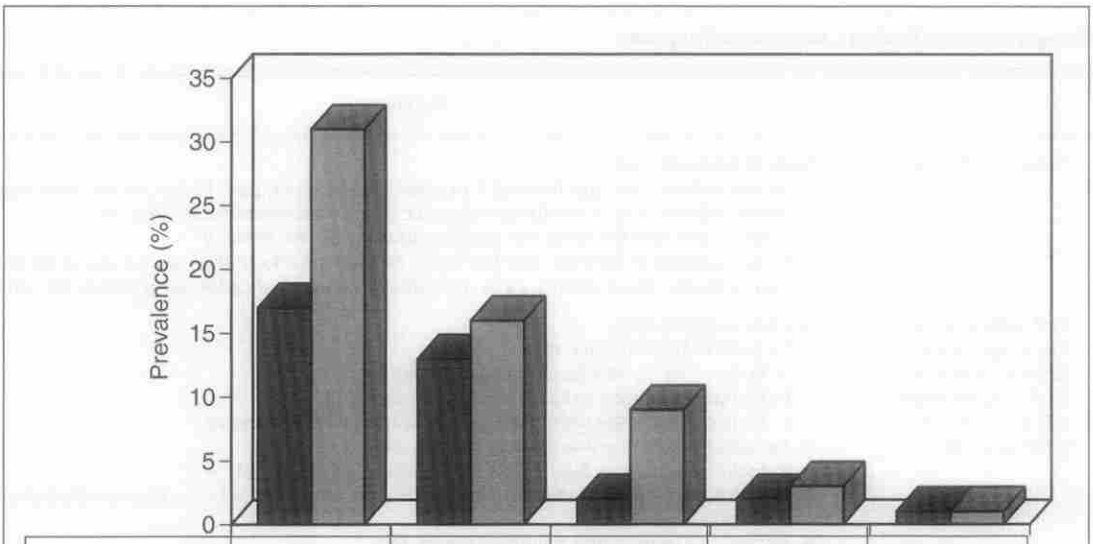
Category	Term	Definition
1	Current asthmatic	Student responds that: 1. he has asthma now and has had 1 or more attacks in the past 12 mo, or has seen a doctor about asthma, or is currently taking medication or treatment for asthma; or 2. a doctor has said the child has reactive airways disease now; or 3. he had asthma in the past, and has had 1 or more attacks in the past 12 mo, or he has ever seen a doctor about asthma, or he is currently taking medication or treatment for asthma.
2	Past asthmatic; severe respiratory disease; current bronchitic; moderate symptoms, but less than a frank asthmatic now	Student responds that: 1. he used to have asthma, and a. he has had no attacks in the past 12 mo, or b. he has never seen a doctor about his asthma, or c. he is not currently taking asthma medication or treatment; or 2. he used to have reactive airways disease; or 3. a doctor said he now has, or has had, chronic bronchitis; or 4. he has had episodes of shortness of breath with wheezing or he is occasionally bothered by such attacks; or 5. he has 4 or more of the following symptoms: a. cough on most days in past 3 mo, b. chest sometimes sounds wheezy or whistling, c. episodes of shortness of breath with wheezing, d. wheezes with chest tightness, and/or e. is troubled by shortness of breath when walking or running.
3	Mild respiratory symptoms	Student responds that he has 2 or 3 of the following symptoms: 1. cough on most days in the past 3 mo, 2. chest sometimes sounds wheezy or whistling, 3. episodes of shortness of breath with wheezing, 4. wheezes with chest tightness, 5. is troubled by shortness of breath when walking or running, and/or 6. is more short of breath than most children of the same age.
4	Minimal or no respiratory symptoms	None of the aforementioned combinations.

Table 2.—Baseline Questionnaire Response Summary

Question	Responses	Nogales, Arizona (n = 328)		Nogales, Sonora (n = 303)		p (difference between Arizona and Sonora)
		Frequency	%	Frequency	%	
Gender	Female	145	44.2	134	44.2	> 0.10
	Male	183	55.8	169	55.8	
Frequent cough during past 3 mo	Yes	97	29.6	51	16.8	0.01
Chest ever sounds wheezy	Yes	116	35.6	89	29.6	0.001
Episodes of shortness of breath with wheezing	Yes	92	28.1	68	22.5	0.08
Doctor-declared asthma	Yes, still	17	5.2	11	3.6	> 0.10
	Yes, but no more	14	4.3	10	3.3	
Doctor-declared reactive airways disease	Yes, still	5	1.5	4	1.3	>0.10
	Yes, but no more	15	4.9	10	3.3	
Serious lung disease prior to age 3 yr	Yes	11	3.4	15	5.0	> 0.10
Environmental factors						
Smokers living in the home	Yes	138	43.0	179	59.3	0.001
Someone smokes in the home	Yes	131	42.0	151	50.0	0.001
Hay fever reported		73	22.5	23	7.6	0.05

central heating. In each town, we used multivariate analysis to examine the relationships between these factors and asthma/respiratory disease. Except for environmental tobacco smoke (ETS), none of the factors were related significantly to the respiratory prevalence rates.

The rates for someone smoking inside the home were 42% in Arizona and 50% in Sonora. In Arizona, smoking in the home was associated with a relative risk of 2.3 (confidence interval [CI] = 1.07, 4.98) for current asthma, 2.9 (CI = 1.78, 4.93) for moderate/severe symp-



	Nasal Symptoms	Cough	Sputum production	Wheezing	Inhaler use
Nogales, Arizona	17	13	2	2	1
Nogales, Sonora	31	18	9	3	1

Fig. 1. Daily prevalence rates (%) for respiratory symptoms.

toms, and 1.12 (CI = 0.80, 1.75) for mild symptoms. Smoking inside the home on the Sonora side was associated with a relative risk of 1.25 (CI = 0.56, 2.83) for current asthma, 1.87 (CI = 1.1, 3.12) for moderate/severe symptoms, and 1.01 (CI = 0.59, 1.74) for mild symptoms. The relative risks were not significantly different between Arizona and Sonora for any of these categories.

Daily diary results. On the Arizona side, the average daily prevalence rate of nasal symptoms was 18%, compared with 30% on the Sonoran side—a significant difference ($p < 0.001$). Cough prevalence rates were 13% and 18%, respectively ($p < 0.001$), and daily sputum production was 2% and 9%, respectively ($p < 0.001$). Daily wheezing (2–3%) and inhaler use (1%) were low on both sides and were not significantly different (Fig. 1). We also created a classification that we defined as a student's diary notation of any 1 of the following symptoms: nasal symptoms, cough, or sputum production. Significantly larger daily prevalence rates of such symptoms were seen on the Sonoran side (38%) than on the Arizona side (24%).

We again used information from the diaries to create another classification by combining a student's notation of any 1 of the following symptoms: wheezing, shortness of breath, or inhaler use. The daily average prevalence rate for this classification on the Arizona side was 2%, and on the Sonora side was 3%.

The levels of particulate matter were somewhat higher on the Sonoran side of the border than on the Arizona side. Mean PM_{10} during the time of the study was 57.9 $\mu g/m^3$ in Nogales, Arizona, and 104.1 $\mu g/m^3$ in Nogales, Sonora ($p < 0.001$). On the Arizona side, on no days did levels exceed 150 $\mu g/m^3$, whereas in Sonora this level was exceeded on 8 days. Regression analysis of the relationship between daily PM_{10} and average daily symptom rates showed a significant association between higher daily PM_{10} levels and higher daily prevalence rates of respiratory complaints on both sides of the border. This was most notable in children classified with asthma (Category 1) or with moderate/severe respiratory symptoms (Category 2). $PM_{2.5}$ levels on both sides of the border were too low for any meaningful analysis. Temperature was not correlated significantly with respiratory symptoms in either city.

Discussion

In this study, we report prevalence rates of asthma and other respiratory conditions in a sample of public school students in sister Arizona-Mexico border communities, and important insights into differences and similarities across the border are provided. Although the prevalence of asthma was similar on both sides of the border, levels appear consistent with those found in other populations in southern Arizona among Hispanic

children (levels that are lower than those in non-Hispanic white children.[36] These similarities are interesting in that the mean ambient PM_{10} was quite different in the 2 cities. On the other hand, cough, phlegm, and nasal symptoms were more prevalent in Sonora, which had a higher ambient PM_{10}.

Several investigations have found that asthma prevalence and severity among urban Hispanics of Puerto Rican ancestry is higher than expected. Hispanics of Mexican descent have generally been reported to have a much lower prevalence rate for asthma.[11]

Allergens, ETS, and other pollutants, as well as viral infections are known environmental factors that induce and/or exacerbate asthma.[12] Other influential factors include poor access to health care, higher levels of immunoglobulin E, family history, and poverty. Asthma is a multifactorial disease associated not only with air pollution, but also with genetics, atopy, allergen exposures (e.g., house dust mites, pets, cockroaches, rodent urine, birds, various pollens and molds), and other factors.[10–12,30] We saw no relationship with the presence of pets in the home; we did not examine the other factors.

Given the large number of children who reported other respiratory symptoms, it is likely that some were undiagnosed asthmatics. The limitations of studies that rely on self-reporting and questionnaires are well known. From a clinical standpoint, a full history, a physical examination, and often diagnostic tests, are required for an asthma diagnosis. One of the major problems in determining the prevalence of asthma in any population is lack of agreement on a "gold standard" for the definition of asthma and the various terms used to study the prevalence of asthma. Some studies rely on patient (or parent) reporting, whereas others combine criteria such as self-reported symptoms and provocation. No real gold standard exists for measuring asthma prevalence for international comparison.

Another term, "reactive airways disease," complicates questions concerning asthma because some individuals have been told that they or their children have reactive airway disease, but asthma has not been mentioned. For many reasons, many symptomatic children may not have been evaluated, diagnosed, or treated for asthma.

Appropriate caution must be exercised in extrapolating the findings of this study to all children. Our study was limited by several factors: (a) the restriction to 5th-grade students (age 10–12 yr), (b) reliance on self-reporting on questionnaires, and (c) lack of direct child follow-up. Furthermore, regarding those questions related to medical judgments, it is unclear whether Mexican physicians use the same criteria as U.S. physicians in describing similar conditions. Studies have shown that the prevalence rates of asthma are highest in early childhood, declining to a low at around 20 yr of age, after which they increase slowly with age.[14] It was, therefore, difficult for us to generalize overall asthma prevalence in these communities, inasmuch as we studied only 10–12-yr–old children.

Differences in prevalence rates between the 2 communities might also be related to the lower socioeconomic status (SES) of the Sonoran community, as asthma and other serious respiratory complaints are reported more frequently in populations with lower SES.[8] We confirmed the SES difference by noting differences in housing and use of air conditioning between the 2 communities. Although we found no difference in asthma prevalence between the communities, perhaps fewer cases of asthma are diagnosed and treated in Sonora than in Arizona, as indicated by the higher rate of serious respiratory symptomology in Sonora. The greater prevalence of serious respiratory symptomology in Sonora might result from a lower SES, more indoor smoking, and/or a higher ambient PM_{10}. We were unable to determine the separate attributable risks for these major factors because of the lack of internal variability in the communities we studied. A more intensive study of these factors, performed in a U.S. community and a Mexican community with sufficient variation and internal and external differences, might assist in the determination of the individual importance of the various factors.

Translation of our questionnaire into Spanish might have introduced another source of bias. Most Arizona children and parents used the English version, and all Sonoran children and parents used the Spanish version. Some of the English terms and phrases were difficult to translate into Spanish; perhaps they might have been interpreted differently. However, as noted in the Materials and Method section, the questionnaires were translated into Spanish by medical personnel familiar with local idioms, and then they were back-translated into English, the purpose of which was verification of the content of each question and minimization of the chance that misinterpretation caused by language differences would affect study results. Results of item analyses of each version differed slightly.

Another limitation was the possibility that patients with moderate-to-severe asthma consulted their physicians more frequently than patients with mild asthma. Many patients may not seek any medical care, or some may self-treat. Therefore, the prevalence of asthma measured by this study might represent an underestimation of the true prevalence. We were unable to examine each patient's chart or to speak directly with each patient's family. Also, caution must be exercised in comparing asthma prevalence estimates from different studies that use different assessment instruments, as assessments can vary depending on how a question is phrased.

An important finding of our study is the large number of children—especially those with some degree of respiratory symptoms—who were exposed to ETS at home.

We recommend continued smoking cessation efforts, with particular emphasis on reducing ETS exposure in the home. Finally, parents should be encouraged to take their children to a health care provider for assessment and treatment, if needed, of chronic and recurrent respiratory problems.

* * * * * * *

The authors would like to thank Ila Titelbaugh, Royce Robbins, and Norm Petersen, as well as Drs. Shan Jin, Luis Ortega, R. Navarro, and E. Davis, for their assistance with this study. They would also like to thank the teachers, school district officials, and especially the parents and children of Ambos Nogales for their help with this project.

This work was supported by a contract from the Arizona Department of Health Services.

Submitted for publication February 25, 2001; revised; accepted for publication July 5, 2002.

Requests for reprints should be sent to George A. Stephen, M.D., Southern Arizona VA Health Care System, 3601 South 6th Ave, Tucson, AZ 85723.

E-mail: stephen@med.va.gov

* * * * * * *

References

1. Weitzman M, Gortmaker SL, Sobol AM, et al. Recent trends in the prevalence and severity of childhood asthma. JAMA 1992; 268:2673–77.
2. Gergen PJ, Mullally DI, Evans R. National survey of prevalence of asthma among children in the United States, 1976 to 1980. Pediatrics 1988; 8:1–7.
3. U.S. Centers for Disease Control and Prevention. Surveillance for asthma—United States, 1960–1995. MMWR 1998; 47(SS-1):1–26.
4. Asher MI, Keil U, Anderson HR, et al. International study of asthma and allergies in childhood (ISAAC): rationale and methods. Eur Respir J 1995; 8:483–91.
5. International Study of Asthma and Allergies in Childhood (ISAAC). Lancet 1998; 351:1225–32.
6. Gergen PJ, Weiss KB. The increasing problem of asthma in the United States. Am Rev Respir Dis 1992; 146:823–24.
7. Sears MR. Epidemiology of childhood asthma. Lancet 1997; 350:1015–20.
8. Lebowitz MD, Spinaci S. The epidemiology of asthma. Eur Respir Rev 1993; 14:415–23.
9. Weitzman M, Gortmaker S, Sobol A. Racial, social, and environmental risks for childhood asthma. Am J Dis Child 1990; 144:1189–94.
10. Katton M, Mitchell H, Eggleston P, et al. The national cooperative inner-city asthma study. Pediatr Pulmonol 1997; 24:253–62.
11. Carter-Pokras OD, Gergen PJ. Reported asthma among Puerto Rican, Mexican-American, and Cuban children 1982–84. Am J Public Health 1993; 83(4): 580–82.
12. Goldstein RA, Plaut M. Urban asthma. Pulmon Perspect 1996; 12:6–8.
13. Strachan DP. The epidemiology of childhood asthma. Allergy 1999; 54:7–11.
14. Magnus P, Jaakkola JJ. Secular trend in the occurrence of asthma among children and young adults: critical appraisal of repeated cross sectional surveys. Br Med J 1997; 314:1795–99.
15. Barbee RA, Dodge R, Lebowitz, MD, et al. 1985. The epidemiology of asthma. Chest 1985; 87(Suppl):21S–25S.
16. Gergen PJ, Mullally DI, Evans RE. National survey of prevalence of asthma among children in the United States, 1976–1980. Pediatrics 1994; 94:356–62.
17. U.S. National Center for Health Statistics. 3rd National Health and Nutrition Examination Survey (NHANES III), 1988–1994. Hyattsville, MD: National Center for Health Statistics, Division of Data Services.
18. Christiansen SC, Martin SB, Schleicher NC, et al. Current prevalence of asthma-related symptoms in San Diego's' predominately Hispanic inner-city children. J Asthma 1996; 33:17–26.
19. McGill KA, Sorkness CA, Ferguson-Page C, et al. Asthma in non-inner city Head Start children. Pediatrics 1988; 102:77–83.
20. Grant EN, Daughterty SR, Moy JN, et al. Prevalence and burden of illness for asthma and related symptoms among kindergartners in Chicago public schools. Ann Allergy Asthma Immunol 1999; 83:113–20.
21. Ertle AR, London MR. Insights into asthma prevalence in Oregon. J Asthma 1988; 35:281–89.
22. Farber HJ, Wattigney W, Berenson G. Trends in asthma prevalence: the Bogalusa Heart Study. Ann Allergy Asthma Immunol 1997; 78:265–69.
23. Venn A, Lewis S, Cooper M, et al. Increasing prevalence of wheeze and asthma in Nottingham primary schoolchildren 1988–1995. Eur Respir J 1998; 11:1324–28.
24. Senthilselvan A. Prevalence of physician-diagnosed asthma in Saskatchewan 1981–1990. Chest 1998; 114:388–92.
25. Kaur B, Anderson HR, Austin J, et al. Prevalence of asthma symptoms, diagnosis, and treatment in 12–14 year old children across Great Britain (International Study of Asthma and Allergies in Childhood, ISAAC, UK) Br Med J 1998; 316:118–24.
26. Sears MR. Epidemiology of childhood asthma. Lancet 1997; 350:1015–20.
27. Prahl P, Christiansen P, Hjuler I, et al. Prevalence of asthma in Danish children aged 8–10 years. Acta Paediatr 1997; 86: 1110–13.
28. Ones U, Sapan N, Somer A, et al. Prevalence of childhood asthma in Istanbul, Turkey. Allergy 1997; 52:570–75.
29. Speight ANP, Lee DA, Hey EN. Underdiagnosis and undertreatment of asthma in childhood. Br Med J 1983; 286:1253–56.
30. Joseph CLM, Foxman B, Leickly FE, et al. Prevalence of possible underdiagnosed asthma and associated morbidity among urban schoolchildren. J Pediatr 1996: 129:735–42.
31. Lebowitz MD. Epidemiological studies of the respiratory effects of air pollution. Eur Respir J 1996; 9:1029–54.
32. Pope CA, Dockery DW. Acute health effects of PM_{10} pollution on symptomatic and asymptomatic children. Am Rev Respir Dis 1992; 145:1123–28.
33. Lebowitz MD, Quackenboss JJ, Kryzyzanowski M, et al. Multipollutant exposures and health responses to particulate matter. Arch Environ Health 1992; 7:71–75.
34. Thurston GD, Lippmann M, Bartoszek M, et al. Air pollution associations with asthma exacerbations, peak flow changes, and respiratory symptoms in children at a summer asthma camp. Am Rev Respir Dis 1993; 1147:A633.
35. Romieu I, Meneses F, Ruiz S, et al. Effects of air pollution on the respiratory health of asthmatic children in Mexico City. Am J Respir Crit Care Med 1996; 154:300–07.
36. Di Pede C, Viegi G, Quackenbush J, et al. Respiratory symptoms and risk factors in an Arizona population sample of Anglo and Mexican–American whites. Chest 1991; 99:916–22.