

HEALTH AND HEALTH CARE FOR HIGH-RISK CHILDREN AND ADOLESCENTS

Inadequate Therapy for Asthma Among Children in the United States

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Abstract. *Objective.* Childhood asthma morbidity and mortality are increasing despite improvements in asthma therapy. We hypothesized that a substantial number of children with moderate to severe asthma are not taking the maintenance medications recommended by national guidelines. The objective of this study was to describe medication use among US children with asthma and determine risk factors for inadequate therapy.

Methods. The National Health and Nutrition Examination Survey (NHANES) III 1988–1994 provided cross-sectional, parent-reported data for children 2 months to 16 years of age. Analysis focused on children with moderate to severe asthma (defined as having any hospitalization for wheezing, ≥ 2 acute visits for wheezing, or ≥ 3 episodes of wheezing over the past year). We defined these children as adequately treated if they had taken a maintenance medication (inhaled corticosteroid, cromolyn, or theophylline) during the past month. Demographic variables were analyzed for independent associations with inadequacy of therapy. The statistical analysis used SUDAAN software to account for the complex sampling design.

Results. A total of 1025 children (9.4%) had physician-diagnosed asthma. Of those with moderate to severe asthma ($n = 524$), only 26% had taken a maintenance medication during the past month. Even among children with 2 or more hospitalizations over the previous year, only 32% had taken maintenance medications. In a logistic regression analysis, factors significantly associated with inadequate therapy included: age ≤ 5 years, Medicaid insurance, and Spanish language. Children surveyed after 1991, when national guidelines for asthma management became available, were no more likely to have taken maintenance medications than children surveyed before 1991.

Conclusion. Most children with moderate to severe asthma in this nationally representative sample, including those with multiple hospitalizations, did not receive adequate asthma therapy. These children may incur avoidable morbidity. Young children, poor children, and children from Spanish-speaking families appear to

be at particularly high risk for inadequate therapy. *Pediatrics* 2000;105:272–276; *asthma, children, maintenance medications, poverty, guidelines.*

ABBREVIATIONS. NHANES, National Health and Nutrition Examination Survey; OR, odds ratio; CI, 95% confidence interval.

Asthma is the most common chronic illness of childhood,¹ and hospitalization rates for childhood asthma have increased despite improvements in asthma therapy.^{2–4} Current national and international guidelines recommend daily use of maintenance medications for all children with moderate to severe asthma.^{5,6} Such medications protect against asthma exacerbations leading to hospitalizations.^{7–10} Despite these recommendations, poor adherence may be common, as suggested by several studies in specific geographic areas.^{11,12} National patterns of preventive medication use among children with asthma have had less description, but it is likely that many children in the United States do not receive medications that might reduce asthma morbidity.

In the United States, asthma disproportionately affects poor and minority populations.^{3,13–16} Children living in the inner-city also use preventive medications suboptimally.^{17–20} This finding may partially explain the discrepancy in asthma morbidity observed between poor and nonpoor children.

We hypothesized that many children with moderate to severe asthma, particularly those living in poverty, do not use the maintenance medications recommended by national guidelines. The objective of this study was to describe medication use among a representative national sample of US children with moderate to severe asthma and to determine risk factors for inadequate therapy.

METHODS

Population and Sampling

The National Health and Nutrition Examination Survey (NHANES) III is a large-scale national survey conducted by the National Center for Health Statistics. Conducted from 1988 through 1994, in 2 phases of equal length and sample size, the survey includes a sample of approximately 40 000 persons. Both Phase I and Phase II include representative samples of the non-institutionalized US population 2 months of age and older living in households. The persons selected were asked to complete an extensive interview and an examination in a mobile examina-

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tion center. The response rate for the interview component of the survey was 86%.

Meeting the goals of NHANES III required precise descriptive information on the health status of selected population groups of the United States and large enough group samples to improve the precision of the information. These subgroups included (but were not limited to) children aged 2 months to 5 years, Black Americans, and Mexican Americans. The NHANES III Household Youth Questionnaire file contains data collected for children and youths 2 months to 16 years of age. The questionnaire was completed for 13 944 children and youths during the 6 years of NHANES III.

Children between the ages of 2 months to 16 years whose parents reported physician-diagnosed asthma were identified from the NHANES III data file. Specifically, respondents were asked whether a physician ever said the child had asthma. Questions also were asked about wheezing without a specific diagnosis of asthma, but we did not include these children because of the lack of specificity for this term. Respondents were also asked about the number of episodes of wheezing, the number of acute health care visits for wheezing (office or emergency department), and the number of hospitalizations for wheezing during the past 12 months. Information pertaining to medication use was collected using interview questions that asked respondents about any prescribed medications used during the past month.

Definitions and Measures

We defined children as having *mild asthma* if they had no hospitalizations, ≤ 1 acute visit for asthma, and ≤ 2 episodes of wheezing over the past 12 months. Children were defined as having *moderate to severe asthma* if they had any hospitalization, ≥ 2 acute visits, or ≥ 3 episodes of wheezing over the past 12 months. Because these definitions of severity are not standardized, a subgroup of children who more clearly have severe asthma (those with ≥ 2 hospitalizations or ≥ 4 acute visits for asthma during the past 12 month) also were evaluated. *Asthma medications* were defined as any medication commonly used for asthma including bronchodilators (albuterol, metaproteronol, isoproterenol, salmeterol, bitolterol, and isoetharine), inhaled corticosteroids (flunisolide, triamcinolone, and beclomethasone), mast cell stabilizers (cromolyn and nedocromil), and theophylline derivatives (oxtriphylline, theophylline). *Maintenance medications* included the inhaled corticosteroids, mast cell stabilizers, and theophylline derivatives. In accordance

with the national guidelines for asthma management,^{5,6} which recommend maintenance medications for all children with moderate to severe asthma, children were defined as *adequately treated* if they met the definition for moderate to severe asthma and had taken a maintenance asthma medication during the past month.

Independent variables included age, gender, race, poverty status (above or below the poverty level, based on reported family income and the US Poverty Threshold produced annually by the Census Bureau), insurance status, preferred language of the family (English or Spanish was spoken by all but 1 family in this series), and whether the child had a specified primary physician. The prevalence of adequate therapy was also determined by phase of the survey (Phase I–1988–1991 and Phase II–1991–1994) to evaluate possible differences in maintenance medication utilization before and after 1991 when national guidelines for asthma management became available.

Analysis

Because NHANES III was based on a complex sampling design, appropriate sample weights were used in the analysis to produce national estimates. SUDAAN software was used to estimate associated variances and to obtain weighted frequencies, odds ratios (ORs), and 95% confidence intervals (CIs).²¹ χ^2 tests were used to test for differences in proportions, and logistic regression was used for the multivariate analysis.

RESULTS

A total of 1025 children (9.4%) had physician-diagnosed asthma. Of these, 524 (51%) had moderate to severe asthma according to study criteria. Table 1 shows demographic characteristics for all subjects in the survey as well as for children with mild asthma and children with moderate to severe asthma. Children with moderate to severe asthma were more likely to be ≤ 5 years old than children with mild asthma ($P = .02$). Gender distribution, race, socioeconomic level, insurance status, preferred language, and presence of an identifiable primary physician did not differ between these groups.

TABLE 1. Population Demographics

	All Subjects (N = 13 944)	Children With Mild Asthma (N = 501)	Children With Moderate to Severe Asthma (N = 524)
Age			
≤ 5 y	36.3%	18.3%	27.2%*
> 5 y	63.7%	81.7%	72.8%
Gender			
Male	51.2%	61.0%	54.7%
Female	48.8%	39.0%	45.3%
Race			
White	77.9%	73.6%	81.7%
Black	16.5%	19.9%	16.0%
Other	5.6%	6.5%	2.3%
Poverty Status			
Below poverty	24.8%	31.2%	23.5%
At or above poverty	75.2%	68.8%	76.5%
Insurance type			
Private	73.9%	71.0%	71.5%
Medicaid	15.8%	19.2%	18.0%
No insurance	10.2%	9.8%	10.5%
Preferred language			
English	92.6%	91.7%	93.7%
Spanish	6.4%	7.5%	6.0%
Other	1.0%	.8%	.3%
Primary physician identified			
Yes	75.8%	77.1%	82.3%
No	24.2%	22.9%	17.7%

* Difference between mild and moderate to severe groups significant at $P < .05$.

TABLE 2. Maintenance Medication Use Among Children With Moderate to Severe Asthma

	Total (N = 524)	Phase I (1988–1991) (N = 253)	Phase II (1991–1994) (N = 271)	P Value
Any maintenance medication	26.0%	24.4%	27.1%	.8
Mast cell inhibitor	7.3%	5.0%	9.0%	.4
Inhaled corticosteroid	7.5%	3.7%	10.4%	.1
Theophylline	15.1%	19.1%	12.1%	.3

TABLE 3. Inadequate Therapy Among Children With Moderate to Severe Asthma

	N	Inadequate Therapy	P Value
Overall	524	74.0%	
Age			
≤5 y	288	86.7%	—
>5 y	236	69.3%	.05
Gender			
Male	309	72.5%	—
Female	215	75.8%	.5
Race			
White	307	73.5%	—
Black	203	75.6%	.8
Other	14	81.2%	.7
Poverty status			
Below poverty	191	87.3%	—
At or above poverty	303	70.3%	.03
Insurance			
Private	289	67.7%	—
Medicaid	160	91.4%	.01
No insurance	53	80.3%	.2
Preferred language			
English	467	72.6%	—
Spanish	56	99.8%	.05
Particular doctor identified			
Yes	430	74.5%	—
No	94	71.9%	.9

— Indicates reference group.

All patients had at least 1 episode of wheezing, and were divided approximately evenly between those with 1 to 3 episodes, 4 to 6 episodes, and >6 episodes during the past 12 months. Twenty-eight percent of patients had no acute visits within the past 12 months, whereas 25% had ≥4 acute visits. Thirteen percent of patients had been hospitalized for wheezing during the past year.

Table 2 shows the use of maintenance medications among the children with moderate to severe asthma during phase I and phase II of the survey. Only 26% of these children had taken a maintenance asthma medication during the past month and therefore were defined as adequately treated. These data were reanalyzed and the results were unchanged when restricted to children >18 months of age, indicating that any uncertainty of diagnosis in the youngest children did not influence the findings. Children surveyed after 1991, when national guidelines for asthma management became available, were no more likely to have taken maintenance medications than those children surveyed before 1991 (24.4% vs 27.1%; $P = .8$). Although not statistically significant, there was a trend toward more inhaled corticosteroid use and less theophylline use among children in the latter phase compared with children in the earlier phase.

Because the definitions for asthma severity used

in this analysis are not standardized, we also evaluated the use of maintenance medications for children in relationship to their number of hospitalizations and acute visits for asthma. Less than 33% of children with 2 or more hospitalizations during the previous year, and <30% of children with 4 or more acute visits over previous year, had taken a maintenance asthma medication during the past month. Thus, therapy was inadequate even among children who repeatedly required health care services for asthma.

Table 3 shows the percentage of children with moderate to severe asthma with inadequate therapy according to demographic characteristics using bivariate analysis. Children ≤5 years of age were more likely to receive inadequate therapy than older children ($P = .05$). Inadequate therapy also was more likely among children below the poverty level ($P = .03$), children with Medicaid insurance ($P = .01$), and children whose preferred language was Spanish ($P = .05$). More than 90% of both children with Medicaid insurance and children who were Spanish-speaking had inadequate therapy. The percentage of children taking maintenance medications did not differ among gender and racial groups nor between those with and without an identifiable primary physician.

The logistic regression analysis indicated that characteristics independently associated with inadequate therapy included age ≤5 years ($P = .005$), Medicaid insurance ($P = .03$), and Spanish language ($P < .001$) (Table 4). Although significant in

TABLE 4. Demographic Factors Associated With Inadequate Therapy for Asthma

Characteristic	OR	95% CI	P Value
Age			
≤5 y	4.48	(1.59, 12.64)	.005
Gender			
Male	.69	(.36, 1.31)	.25
Race			
Black	.55	(.26, 1.18)	.12
Other	.24	(.04, 1.72)	.15
Poverty status			
Below poverty	.97	(.26, 3.69)	.96
Insurance			
Medicaid	4.78	(1.17, 19.51)	.03
No insurance	2.20	(.47, 10.41)	.31
Preferred language			
Spanish	64.60	(9.19, 454.00)	<.001
Particular doctor identified			
No	1.06	(.17, 6.52)	.94

Results from multivariate logistic regression. (Reference = age > 5, female gender, white race, ≥100% poverty, private insurance, english language, and particular doctor identified).

the bivariate analysis, poverty level was not independently associated with inadequate therapy in the multivariate analysis.

DISCUSSION

This study suggests that many children in the United States with moderate to severe asthma do not receive recommended maintenance medications and may suffer avoidable morbidity. The 74% of children with inadequate therapy in this sample represent more than 2 million US children who would likely benefit from maintenance medications. Young children, children with Medicaid insurance, and children from Spanish-speaking families were at highest risk for inadequate therapy.

We designated the asthma severity categories based on reported health care utilization and episodes of wheezing. Approximately 50% of the children with asthma fit our definition of mild asthma, of whom 2.2% had taken a maintenance medication during the past month. This group was distinguished from those with moderate to severe asthma, of whom 26% had taken a maintenance medication. These categories are not the same as those of the National Guidelines for the Diagnosis and Management of Asthma, insofar as NHANES III does not provide the frequency of daily and weekly symptoms used in the guidelines. However, it is likely that there is substantial overlap between our definitions of moderate to severe asthma and the criteria from the National Heart, Lung, and Blood Institute guidelines.

It is possible that some of the children defined as having moderate to severe asthma did not truly require the use of a maintenance medication at the time of the survey. Also, parental report of wheezing “episodes” is subject to individual variation in interpretation, with some parents reporting mild, transient wheezing as an “episode.” However, the percentage of children who did not take maintenance medication was high even in a subgroup of children with the most severe asthma, defined as having ≥ 2 hospitalizations or ≥ 4 acute visits during the past year. This finding is particularly striking because children already involved in the health care system would be more likely to receive recommended therapies than other children.

Our study has some potential limitations. For example, asthma was defined by parental report only, although this strategy was unlikely to alter the detection of those children with moderate to severe asthma, particularly those with multiple acute visits and hospitalizations. Further, the diagnosis of asthma may be less certain in the youngest children. Therefore, we reanalyzed the data including only children >18 months of age to eliminate most of the episodic viral induced wheezing in the youngest children that could be confused with asthma. In this analysis, the percentage of children receiving inadequate therapy remained the same (74%).

We could not determine if medications were appropriately prescribed or the degree of nonadherence by families. It is possible that some of the

children with moderate to severe asthma had taken maintenance medications earlier in the year but had discontinued them by the time of the survey. Further, medication use was defined by whether the medication was taken during the past month, but the specific amount of use during that time was not determined. Although maintenance medications most commonly are administered daily, adherence to a daily regimen was unknown. As with any questionnaire survey, response bias was possible and parents may have exaggerated medication use.²² However, positive response bias and exaggerations of medication use would heighten the validity of the findings by underestimating the magnitude of inadequate therapy.

Because the number of patients in certain subgroups was relatively small, the multivariate analysis could have missed important differences, such as the effect of poverty on adequacy of therapy. Alternatively, the strikingly high ORs indicating risk for inadequate therapy among Spanish-speaking children (OR = 64.6; 95% CI, 9.19–454.0) may reflect the small sample of only 56 Spanish-speaking children (55 of whom had not taken maintenance medications). It is possible that a larger sample would yield a less dramatic OR.

The cause for such a striking deficiency in maintenance therapy for US children with moderate to severe asthma is not clear. Many parents doubt the usefulness of preventive medications for asthma and have concerns about the side effects of these medications.²² Such concerns, as well as difficulty with medication administration, may be particularly relevant for younger children whom we found were at high risk for inadequate therapy. Undermedication is common among poor children with asthma,^{17–20} and therefore it is not surprising that children with Medicaid had lower rates of adequate treatment than children with private insurance. Communication and cultural barriers may be important as suggested by the finding of inadequate therapy in nearly all Spanish-speaking children. Further, the hospitalizations or acute visits of the most severe subgroup of children with asthma may have occurred without a primary care provider's knowledge or supervision. Thus, the lack of preventive therapy could relate to various problems integrating tertiary health services with primary health care.

Children surveyed in the latter phase of NHANES III, after national guidelines for asthma management became available, had no greater likelihood of use of maintenance medications than those surveyed in the initial phase. However, the incorporation of new treatment practices after such guidelines requires appropriate dissemination to clinicians, acceptance of recommendations, and implementation into practice patterns.^{23,24} As observed with immunization patterns, a significant lag time may occur before actual changes in practice.²⁵ Even though the latter phase of the survey continued 3 years after national guidelines became available, physicians may not yet have adopted these clinical practices. As more recent data are

accumulated, this analysis could be repeated to reassess changes in asthma therapy and the application of guidelines.

Many researchers have focused on poor, and inner-city children in considering the problem of increasing asthma prevalence and severity. Our data suggest that, while poor children are at particularly high risk for deficiencies in preventive and maintenance care, most children receiving inadequate preventive medications are not poor. Evaluating treatment practices for *all* children with asthma will likely require several levels of consideration, including improved education for practitioners about guidelines for care, integration of tertiary and primary health care systems, improved communication with families and education about the utility of medications and their side effects, and improved access to health care. Closing the gap between therapeutic recommendations and utilization of such therapies could prevent significant morbidity among children with asthma.

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