

The economic burden of asthma in US children: Estimates from the National Medical Expenditure Survey

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Background: Asthma is the leading chronic illness of childhood, is responsible for substantial pediatric morbidity, and has a significant impact on use of health resources.

Objective: Our purpose was to assess the per capita impact of pediatric asthma on medical care utilization and total expenditures.

Methods: A population-based national probability survey, the National Medical Expenditure Survey, was conducted in 1987 to determine the use and cost of health care services in the United States. We analyzed the responses for all children aged 1 to 17 years with (n = 667) and without (n = 6911) asthma. Children with asthma were identified with use of a population-based screening question. Frequency and cost of medications, ambulatory visits, emergency department care, and hospitalizations for all reasons, including asthma, were assessed.

Results: The period prevalence of childhood asthma in 1987 was 8.8% and the treated prevalence (any asthma medications) was 4.0%. Forty-one percent of families with asthmatic children were classified as having no primary insurance. Children with asthma used substantially more services in all categories of care: 3.1 times as many prescriptions, 1.9 times as many ambulatory provider visits, 2.2 times as many emergency department visits, and 3.5 times as many hospitalizations. Only 10.7% of children with asthma were defined as chronic users of medications. Children with asthma incurred an average of \$1129 (SD \$5310) per child per year in total health care expenditures compared with \$468 (SD \$2960) for children without asthma, a 2.8-fold difference.

Conclusion: Asthma has considerable impact on the use and costs of medical care services among US children. Data from the 1987 National Medical Expenditure Survey provide a useful baseline against which more recent, postguideline data should be compared. (*J Allergy Clin Immunol* 1999;104:957-63.)

Key words: Cost of illness study, health economics, National Center for Health Statistics

Abbreviations used

ED:	Emergency department
GHC:	Group Health Cooperative of Puget Sound
ICD-9:	International Classification of Diseases, 9th Revision
MEPS:	Medical Expenditure Panel Survey
NMES:	National Medical Expenditure Survey

Asthma is the most common chronic illness in adolescents and children, affecting an estimated 2.7 million US children according to the National Health Interview Survey.¹ The prevalence of asthma appears to have increased in recent decades as measured by diagnostic criteria and the use of acute care services for asthma.² The burden of asthma on children and families is substantial. Children with asthma have a 3-fold greater risk of school absence than do children without asthma.³ Almost 30% of children with asthma have some limitation in activity compared with 5% of children without asthma.¹

A variety of national surveys, including the National Health Interview Survey, the National Hospital Discharge Survey, the National Ambulatory Medical Care Survey, and others, have been used to assess the magnitude of health care utilization and cost among children with asthma. In 1988 children with asthma had an additional 12.9 million contacts with physicians and 200,000 hospitalizations compared with children without asthma.¹ Direct expenditures for children with asthma in 1985 were estimated to be \$465 million.⁴ However, because none of these national surveys collect both diagnostic and expenditure data, per capita costs cannot be estimated for an individual child or family.

More recently, managed care data systems have been used to describe the epidemiologic characteristics of pediatric asthma and the associated utilization and cost within specified enrollee populations.^{5,6} However, these populations cannot be considered to be nationally representative.

The 1987 National Medical Expenditure Survey (NMES) affords the opportunity to study health care use and expenditures for persons with asthma in a national sample weighted to represent the US population.^{7,8} This population-based survey collected information on various categories of health care utilization and expenditure, including prescriptions, ambulatory visits, emergency department (ED) visits, and hospitalizations. Information on the respondents' insurance status and out-of-pocket

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TABLE I. Demographic characteristics of respondents in 1987 NMES (weighted)

	Children with asthma (%)	All children (%)
Age (y)		
1-4	30.1	24.6
5-9	23.5	27.9
10-17	46.4	47.5
Sex		
Male	56.5	50.9
Race		
White	74.6	77.1
Nonwhite	25.4	22.9
Insurance type		
Private	30.4	26.0
Public	16.8	12.5
Self-pay	40.7	34.9
Other/unknown	12.1	26.6
Family income		
<\$30,000/y	50.4	48.9

contributions was also collected. NMES has been used to estimate national and per capita expenditures for persons with asthma (all ages) and to identify high-cost subpopulations.⁹

In this study, we used the NMES to:

- Define the epidemiology of childhood asthma in this national sample
- Characterize medication use among children with asthma
- Measure health care utilization and expenditures by children with asthma, within various categories of care, compared with children without asthma and with the general population
- Compute the proportion of utilization and cost attributable specifically to asthma-related care, within various categories of care
- Estimate expenditures by children with asthma stratified by type of insurance

METHODS

The 1987 NMES, administered by the Agency for Health Care Policy and Research (AHCPR), was a national probability sample of approximately 35,000 individuals representative of the non institutionalized, civilian US population. The NMES collected person-level information on demographics, health insurance coverage, all health care encounters, and expenditures. Expenditures in the NMES reflect total payments (rather than charges), including out-of-pocket and those made by third-party payers. Interview data on health care use and expenditures were supplemented by a separate medical provider survey to reduce potential bias from relying solely on self-reported data. The medical provider survey focused on medical events, where self-reporting was expected to be least reliable and where inaccurate or missing data would have the greatest impact on the precision of expenditure estimates. In particular, high-cost episodes of care involving multiple providers (eg, hospital

stays) and persons with comprehensive coverage were targeted. Expenditures in the NMES are in 1987 dollars.

For our sample, we selected all individuals in the NMES survey who were between 1 and 18 years old. All information collected from these persons was provided by proxy from the parent or guardian. Children were classified as having asthma if the respondent answered affirmatively when asked, "Within the past 12 months, did this child have asthma or wheezing?"

Estimates of per capita use and cost were made for ambulatory care visits, hospital inpatient stays, ED visits, and prescribed medicines. Self-treatment with over-the-counter medications or use of alternative health services were not included in the NMES. Each medical encounter and prescription was assigned at least one International Classification of Diseases, 9th Revision (ICD-9) code. Hospitalizations included up to four ICD-9 codes. An encounter associated with an ICD-9 code of 493 was considered to be asthma-related care. All expenditures are rounded to the nearest dollar.

To assign an insurance type (private, public, self-pay, and other) to each child, the insurer who paid the majority of all medical expenditures (asthma and nonasthma) was designated as the primary insurer. All state and federal health insurance programs were combined into the category "public insurance." Children for whom the majority of expenditures were out of pocket were classified as "self-pay." Thus self-pay constitutes a heterogeneous group of children some of whom had partial coverage through an insurance program and others who were completely uninsured. Children with zero medical expenditure were assigned an insurance type on the basis of NMES survey questions about primary payer for the entire household.

The NMES survey method required the use of individually assigned weights to compute point estimates and SDs for the US population. SUDAAN software¹⁰ was used for these computations.

RESULTS

Demographics

There were 7578 children aged 1 to 17 years in the NMES database. Of these, 667 were reported to have asthma by the responding parent (period prevalence 8.8%). There were more males, younger children, and nonwhites among the children with asthma compared with all children (Table I). Children in the various insurance categories were equally represented among the asthma and nonasthma samples, with the exception of those whose insurance was unknown/other, where the prevalence of self-reported asthma was approximately half that of the other insurance groups. The proportion of families with income less than \$30,000 was similar in the asthma and nonasthma samples (50.6% vs 48.9%, respectively).

Asthma medication use

US children with asthma filled an average of 2.0 prescriptions for asthma during 1987. However, more than

half (55.8%) of children with asthma reported taking no asthma medications. This proportion varied with age, ranging from 44% in 1- to 4-year-old children to 64% in those 10 to 17 years old. Two hundred ninety-five (44.2%) children with asthma reported taking any asthma medications during the year (treated prevalence 4.0%). One hundred forty-nine (22.3%) used a single class of asthma medication, 99 (14.8%) used 2 classes, and 53 (7.9%) used 3 classes. The most commonly reported medication regimens are shown in Table II. Negligible numbers of children were receiving inhaled cromolyn sodium (Intal) or atropine. Chronic users of asthma medications (defined as children who filled at least 3 prescriptions for any asthma medications during the year) comprised 10.7% of the children with asthma.

Health care utilization

US children with asthma reported an average of 0.9 ambulatory care visits per year for asthma in 1987. They had an average of 0.12 ED visits and 0.04 hospitalizations per year for asthma (Table III). Among children with asthma, nonasthma care accounted for the majority of care received in each of these categories: 59.3% of prescriptions, 86.9% of ambulatory visits, 75.0% of ED visits, and 71.4% of hospitalizations (Table III). Eighty-two (12.3%) children with asthma reported no health care utilization.

To further explore the high rate of hospital admissions that were not attributed to asthma among 1-to 4-year-old children (0.19 hospitalization per child per year), we examined the discharge diagnoses for all 39 nonasthma admissions made by children with asthma in the sample. Among these, 47.8% were for respiratory syndromes, including pneumonia, chest symptoms, bronchopneumonia, bronchiolitis, and bronchitis.

Among children with asthma, utilization (Table III) and expenditures varied by age group. The youngest children (1-4 years) used more services than the 10- to 17-year age group did, who in turn used more services than the 5- to 9-year group. In contrast, among children without asthma, utilization expenditures decrease with increasing age so that adolescents use the least amount of services and preschoolers the most.

Comparing all services used (both asthma and nonasthma care) between children with and without asthma, we found that children with asthma used substantially more services in all categories of care: 3.1 times as many prescriptions, 1.9 times as many ambulatory visits, 2.2 times as many ED visits, and 3.5 times as many hospitalizations (Table III). Within each category, the proportion of the utilization difference accounted for by asthma care is 60.4% for prescriptions, 27.8% for ambulatory visits, 46.2% for ED visits, and 40.0% for hospitalizations.

Health care expenditures

Mean asthma-related per capita expenditures totaled \$171 (SD \$779) per year for US children with asthma. The mean yearly asthma-related expenditures by category

TABLE II. Most common asthma medication regimens used by US children with asthma based on of the 1987 NMES

Regimen	Frequency (%) [*]
β-Agonist only	15.4
β-Agonist plus theophylline	10.4
Theophylline only	6.1
β-Agonist plus corticosteroid	2.7
Theophylline plus corticosteroid	2.1
Theophylline plus cromolyn	2.6
β-Agonist plus cromolyn	2.5

^{*}Frequencies represent weighted population estimates. Children taking no asthma medications represented 55.8%. Other combinations accounted for 2.4%.

ry of service were \$34 (SD \$100) for asthma prescriptions, \$31 (SD \$138) for ambulatory visits for asthma, \$18 (SD \$119) for asthma ED visits, and \$87 (SD \$701) for asthma hospitalizations (Table IV). Nonasthma care accounted for 84.9% of all health care expenditures by children with asthma (Fig 1). Among the 87.7% of children with asthma who used any health care services, the mean yearly asthma-related expenditures were \$190 (SD \$819). Mean asthma-related expenditures within the categories of service varied little across age strata, with the exception of hospitalization charges, which were \$175 (SD \$909) for children aged 1 to 4 years, \$49 (SD \$684) for children aged 5 to 9 years, and \$50 (SD \$530) for children aged 10 to 17 years.

Fig 2 shows the distribution of asthma-related expenditures, with ED and hospital care accounting for 61.7% of the total. The distribution for children with asthma who used health care was very similar to that of all children with asthma.

Comparing all expenditures (for both asthma and nonasthma care) between children with and without asthma, we found that children with asthma incurred substantially more expenses in all categories of care. Mean total yearly per capita expenditures for children with asthma were 2.8 times greater than those for children without asthma (Table IV). Only 24% of this total expenditure difference is accounted for by asthma care.

In addition to comparing children with asthma to those without asthma, we also present the distribution of expenditures for all children (Fig 1) because this may be useful when assuming a population-based perspective. Children with asthma incurred an average of \$1129 (SD \$5310) per child per year in total health care charges compared with \$468 (SD \$2960) for the general population of children, a 2.4-fold difference (Fig 1). Note that the \$18 per child per year in asthma care incurred by the general population of children represents charges for asthma care (mean \$15 per child per year) received by children with asthma as well as a small amount of charges (\$3 per child per year) for asthma care reported by children who did not report having asthma.

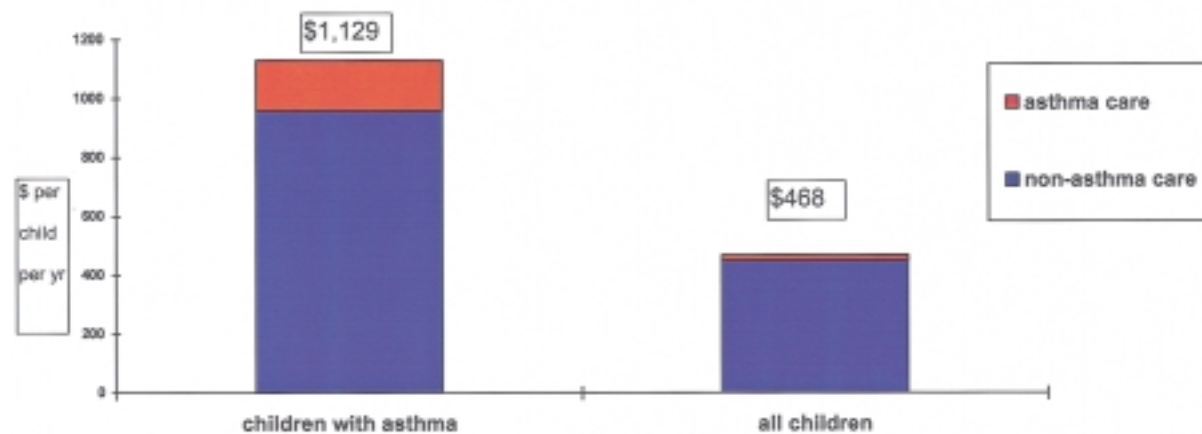


FIG 1. Distribution of expenditures for asthma care and nonasthma care for US children aged 1 to 17 years on the basis of the 1987 NMES. All expenditures are in 1987 US dollars and represent weighted population estimates. All children incurred \$18 per child per year in asthma care, 4% of all expenditures. This represents charges for asthma care received by children with asthma (who were not excluded from "all children") as well as a small amount of charges (\$3 per child per year) for asthma care reported by children who did not report having asthma.

TABLE III. Health care utilization by US children aged 1 to 17 years with and without asthma based on the 1987 NMES

	Prescriptions (mean [SD])	Ambulatory visits (mean [SD])	ED visits (mean [SD])	Hospitalizations (mean [SD])
Children without asthma				
Total: age 1-17 y (n = 7578)				
All care	1.6 (2.9)	3.6 (8.4)	0.22 (0.61)	0.04 (0.24)
Children with asthma				
Total: age 1-17 y (n = 667)				
All care	4.9 (6.9)	6.7 (10.0)	0.48 (1.01)	0.14 (0.53)
Asthma care	2.0 (4.8)	0.9 (4.3)	0.12 (0.58)	0.04 (0.25)
Age 1-4 y (n = 201)				
All care	6.1 (6.2)	8.6 (10.1)	0.79 (1.32)	0.27 (0.77)
Asthma care	1.8 (3.6)	0.8 (3.4)	0.15 (0.54)	0.08 (0.38)
Age 5-9 y (n = 163)				
All care	4.8 (7.2)	5.1 (7.9)	0.34 (0.74)	0.06 (0.26)
Asthma care	2.1 (4.6)	0.8 (2.5)	0.12 (0.57)	0.01 (0.10)
Age 10-17 y (n = 303)				
All care	4.2 (7.1)	6.4 (10.8)	0.36 (0.85)	0.08 (0.41)
Asthma care	2.1 (5.4)	1.0 (5.4)	0.10 (0.61)	0.02 (0.18)

All n values in this table represent actual number of children in each subgroup in sample. Mean utilization rates and SDs represent weighted population estimates.

Expenditures by children with asthma stratified by primary insurance

Mean total per capita expenditures for children with asthma stratified by type of primary insurance are shown in Table V. Compared with children with private insurance, children covered by public insurance programs incurred 0.43 times as many health care expenditures for all care and 1.5 times as many for asthma care. Children classified as self-pay incurred 0.13 and 0.33 times as many expenditures for all care and asthma care, respectively, compared with privately insured children.

The distribution of asthma care expenditures differed greatly among the 3 insurance groups. The proportion of

asthma-related expenditures represented by prescriptions varied from 7.3% for publicly insured children, to 17.5% for privately insured, to 52.8% for uninsured. ED expenses accounted for 15.1% of asthma expenses for publicly insured children but only 6.4% and 9.7% for privately insured and uninsured children, respectively. Among private and publicly insured children, hospitalizations accounted for approximately 60% of asthma expenditures, whereas they made up only 10.5% of those for uninsured children.

Among children whose primary insurance coverage was private, the private carrier paid for 91.6% of health care expenditures. Likewise, Medicaid paid for 94.2% of expenditures for those primarily insured by Medicaid.

Expenditures incurred by children classified as self-pay were covered by a combination of sources: 76.3% by the family and 20.8% by a private health insurance.

Utilization among children with asthma stratified by race group

White children with asthma filled more prescriptions for all care (1.59-fold) and for asthma care (1.19-fold) compared with nonwhite children. Rates of ambulatory asthma visits were comparable, although nonwhites had about half the overall rate of ambulatory visits as whites. Both race groups had similar rates of nonasthma ED visits, but nonwhite children had 5 times as many ED visits for asthma as white children. Nonwhite children were hospitalized for asthma 3.5 times as often as white children.

DISCUSSION

The NMES sample had a period prevalence of asthma of 8.8% and a treated prevalence of 4.0%, rates comparable to other national surveys.^{1,11} Although most children reported as having asthma were taking relatively few asthma medications, almost 11% were receiving chronic asthma treatment. β -Agonists and theophylline, either alone or in combination, were the most common regimens reported among the 45% of children who used asthma medications. The uncommon use of inhaled anti-inflammatory medication reflects standard practice during the years preceding the national asthma guidelines.¹² These data provide a useful baseline from which to gauge practice change after dissemination of the National Asthma Education Program's guidelines in 1991 and again in 1997.

We found that among children with asthma aged 1 to 4 years, there was a relatively high proportion (70%) of hospitalizations for nonasthma care. Almost half of these hospitalizations were for some type of respiratory illness. If hospitalization for respiratory illness is more likely to occur because the child has asthma, this finding might suggest that asthma contributes at least some additional morbidity above what is indicated as being the result of asthma from self-report. This is speculative, however, because we don't know how many of the hospitalizations among all children of this age were for respiratory care.

Children with asthma used substantially more services than children without asthma in all categories of service: 3.1 times as many prescriptions, 1.9 times as many ambulatory visits, 2.2 times as many ED visits, and 3.5 times as many hospitalizations. (The large SDs for both utilization and expenditures reflect the greatly skewed distribution of these variables in the general population, with many low utilizers of care and a small number of high utilizers.) Total health care utilization and expenditures for children with asthma and the general populations were of the same order of magnitude as found in a study of a children enrolled at Group Health Cooperative (GHC) of Puget Sound, a staff-model health maintenance organization.⁶ Likewise, the ratio of utilization between

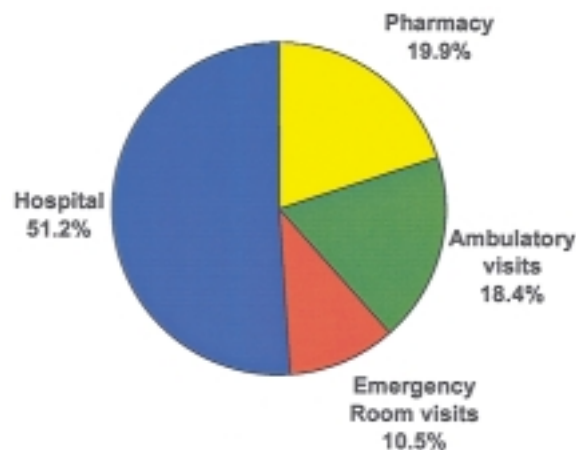


FIG 2. Distribution of asthma-related expenditures for US children with asthma aged 1 to 17 years by category of service, on the basis of the 1987 NMES. Total asthma-related costs = \$171 per child per year. All expenditures are in US dollars and represent weighted population estimates.

children with and without asthma was comparable between NMES and the GHC population within each category of service. These 2 populations differed markedly, however, in asthma hospitalizations. In NMES, fully half of asthma-related expenditures were the result of hospitalizations whereas hospitalizations represented only one fourth of asthma-related expenditures in the GHC population.⁶ The U-shaped effect of age on utilization and expenditures among children with asthma in NMES was also found in another pediatric managed care population.⁵

Overall health care expenditures for children with asthma were 2.8-fold higher than for children without asthma in NMES compared with the 2-fold difference found in the GHC population. In both populations most of the difference in total health care expenditures between children with and without asthma was accounted for by care that was reported as nonasthma care.

A comparison of absolute expenditures in these 2 populations would need to account for a number of complex factors, including different time periods (1987 US dollars vs 1992 US dollars) as well as the diversity of health care settings and demographics included in the NMES. Interestingly, total expenditures for children with asthma were 6% higher in the earlier NMES sample relative to GHC, whereas total expenditures for children without asthma were 32% higher in the more recent GHC cohort relative to NMES. Because of the various differences between the studies, it is difficult to draw any conclusions about these absolute figures.

An additional methodologic factor may partly account for the lower expenditures for asthma-related health care in the NMES sample: \$171 per child with asthma per year compared with \$300 to \$500 in the 2 managed care studies.^{5,6} The NMES method relied on family member respondents to classify health care encounters as asthma related, whereas methods using automated diagnostic

TABLE IV. Health care expenditures by US children aged 1 to 17 years with and without asthma based on the 1987 NMES

	Prescriptions (mean \$ [SD])	Ambulatory visits (mean \$ [SD])	ED visits (mean \$ [SD])	Hospitalizations (mean \$ [SD])	Total (mean \$ [SD])
Children without asthma					
All care	31 (503)	170 (462)	32 (112)	174 (2464)	407 (2634)
Children with asthma					
All care	73 (139)	301 (738)	67 (186)	688 (5098)	1129 (5310)
Asthma care	34 (100)	31 (138)	18 (119)	87 (701)	171 (779)
Expenditure ratio (all care)	2.3	1.8	2.1	3.9	2.8

All expenditures are in 1987 US dollars and represent weighted population estimates. Component costs may not equal total because of rounding. Expenditure ratio is computed as expenditures for all-care children with asthma divided by expenditures for all-care in children without asthma.

TABLE V. Expenditures by US children with asthma aged 1 to 17 years, by primary insurance and distribution of expenditures, for all care and asthma care and categories of service, on the basis of the 1987 NMES

	Total expenditures (mean \$ [SD])		Proportion of total asthma expenditures in each category (%)			
	All care	Asthma care	Prescriptions	Ambulatory visits	ED visits	Hospitalizations
Private	2541 (9303)	238 (968)	17.5	16.5	6.4	59.6
Public	1095 (1979)	353 (1242)	7.3	17.8	15.1	59.8
Self-pay	334 (518)	78 (264)	52.8	26.9	9.7	10.5

All expenditures are in 1987 US dollars and represent weighted population estimates.

data rely on provider diagnosis. This hypothesis is supported by the smaller fraction of total care represented by asthma care: 15% in the NMES compared with 37% in the GHC study.⁶ It may be that either a portion of "nonasthma" care in NMES is misclassified or that administrative data systems may be overreporting asthma expenditures.

Greater use of EDs and hospitalization among non-whites in the NMES reflects the greater asthma burden among African Americans that has been noted in other US populations.¹³⁻¹⁶ Racial group differences in hospitalization rates in our sample were similar to those seen in the National Hospital Discharge Survey.¹⁶

The NMES provided a unique opportunity to examine health care expenditures for children with asthma covered under different types of insurance. About one third of children with asthma had private insurance as their primary coverage, 17% were publicly insured, and for about 40% of these children families reported paying a majority of their health care expenditures out of pocket (self-pay). The public debate on public health care spending has focused in recent years on Medicaid and other programs for the poor. Data from the NMES can be used to put such spending in perspective at an individual level. For example, although publicly insured children accrued only about half as much in total health care expenditures as their privately insured peers, they accrued 1.5-fold more asthma-related expenditures.

Children in different insurance categories had very different distributions of expenditures across categories of service. Frequent use of ED services among low-income, publicly insured children has been reported in numerous studies¹⁷ and is seen also in the NMES. The strikingly smaller fraction of asthma expenditures

accounted for by hospitalizations among self-pay children (10.5% vs approximately 60% for the other insurance categories) may reflect the practice of hospitals determining the Medicaid eligibility of uninsured children and securing Medicaid enrollment on admission or shortly thereafter.

Our study has several limitations. Because drug regimens have evolved in the interim since 1987, we cannot extrapolate from the medication use patterns seen in the NMES sample to current practice. It is also possible that dissemination and implementation of asthma guidelines have improved asthma care in the past decade and resulted in a change in the use of ED and hospital services. No national expenditure data are available between 1987 and 1996 when the Medical Expenditure Panel Survey (MEPS), which replaced the NMES, was conducted. Future studies should examine data from the 1996 MEPS to assess the change in medication use and health care utilization patterns in the postguidelines era. Data from the MEPS is due to be released by the end of 1999.

In addition, by relying on patient report, the NMES method is vulnerable to reporting biases arising from the parent's perception of medical services used. As suggested above, these could result in misclassification of the reason for the medical visit or medication type as well as underreporting (or possibly overreporting) of utilization.

The 1987 NMES provides a useful means of estimating the considerable impact of childhood asthma on the use of health services and expenditures for these services. It may not be as useful in attributing health care to a specific diagnosis. The analyses presented here should serve as a baseline when examining changes in health care utilization and expenditures among children with asthma.

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