NATIONAL COSTS OF ASTHMA FOR 1997

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ABSTRACT

This paper reviews available national cost of asthma estimates and updates them to 1997, accounting for increases in prices of medical goods and services, changes in the usage of asthma-related medical goods and services, and changes in asthma prevalence and mortality. Available estimates were based on original data from the mid-1980s. The national costs of asthma at that time ranged from $4.5 to $5.0 billion. These estimates include direct costs, which are medical expenditures (e.g., for hospitalizations and emergency room visits), and indirect costs, which are lost wages and productivity as a result of asthma-related morbidity (e.g., lost school and work days) and mortality. The best estimate of the national costs of asthma in 1997 is between $8 billion and $11 billion, with direct medical expenditures representing 55% to 70%, indirect morbidity costs representing 15% to 30%, and indirect mortality costs representing about 15%.

Asthma prevalence increased by nearly 70% from 1984-1986 to 1995-1996, far outpacing the 12% growth in population. However, accounting for a doubling in the medical price index, the average costs per person with diagnosed asthma have decreased, in real terms, over this period. Asthma-related outcomes such as hospitalizations, emergency room visits, physician visits, and mortalities have declined on a per-asthmatic basis, suggesting that changes in treatment and management of asthma may be having a positive impact. This is consistent with the roughly doubling in prescription medication expenditures, even after accounting for the substantial increases in prescription prices during this period. This reflects a growing reliance on prescription medications to control asthma symptoms. However, there is some indication that prescription medication use is still not at a level recommended by the medical experts for optimal management of asthma symptoms.

In addition, this paper shows that the financial burden of treating asthma falls more directly on the patients and their families, with out-of-pocket expenses estimated at roughly 25% of total medical costs, compared to 10% for medical expenses for all illnesses. This difference is attributed largely to less coverage for asthma-related expenses by Medicare, reflecting its general low coverage for prescription medications, which represent the largest category of asthma-related medical expenses, and the younger ages typical of asthma patients relative to other common illnesses.

1. INTRODUCTION

Asthma is a chronic respiratory disease that afflicts about 5% of the U.S. population (NCHS, 1998). The "Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma" (EPR-2) (U.S. Department of Health and Human Services, 1997, p. 8) provides the following working definition of asthma:

> Asthma is a chronic inflammatory disorder of the airways. . . . In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment.

Treating asthma's underlying symptoms and providing care for episodic exacerbations imposes costs on individuals with asthma, their families, and society. These costs include direct expenditures for medical goods and services (e.g., prescription medications and physician visits) and lost income and productivity from missed work and school.

This paper presents a literature review of the most recent comprehensive estimates of the annual costs of asthma in the United States. In addition, because these estimates are based on data that are more than 10 years old, this paper updates the previous estimates, accounting for changes in the prices of medical goods and services, asthma-related outcome occurrences (e.g., hospitalizations and deaths), and asthma-related prescription medication usage. Annual estimates of the cost of asthma are developed for those younger than 18 years of age, those age 18 and older, and all ages. Section 2 provides an overview of what is included in cost-of-illness estimates for direct medical expenditures and the value of lost productivity and income associated with a disease. Section 3 reviews available national cost of asthma estimates. Section 4 presents the techniques and data used to update the original national cost of asthma estimates to 1997, as well as estimates based on recent health care expenditure survey data. Section 5 reports how these asthma-related costs are allocated among various payer groups. Section 6 provides concluding remarks.

2. COST OF ILLNESS

Cost-of-illness (COI) estimates are a measure of a disease's financial burden based on the combined value of disease-related direct expenditures for medical goods and services and the value of disease-related lost income and productivity. Examples of direct medical expenditure categories in the Health Care Financing Administration's (HCFA's) national health expenditure accounts include:

- hospital care (inpatient and outpatient)
- physicians' services

- nursing home care
- home health care
- drugs and other medical nondurables
- vision products and other medical durables.

Direct medical expenses are generally linked to a specific disease or condition through the use of standardized diagnoses codes: the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) (U.S. Department of Health and Human Services, 1998). Using these codes, it is possible, for example, to identify all hospital expenses for patients with a primary diagnosis of asthma (ICD-9-CM = 493). If diagnosis codes are unavailable, it still is possible to allocate expenditures to a specific disease or condition if certain services or products are used primarily for treatment of that disease. Alternatively, medical experts can develop allocation shares that distribute expenses among various diseases or conditions.

Indirect costs included in COI estimates are based on the value of disease-related lost income and productivity, which are typically valued using age- and sex-adjusted average wages. The total value of the lost income and productivity is estimated based on the distribution of disease-related outcomes across age and sex categories.[1] Indirect morbidity costs value the lost income and productivity for nonfatal disease-related outcomes (e.g., lost work days, lost school days, and days spent in bed). Indirect mortality costs are based on the present value of expected future earnings that are lost because of a disease-related death.

COI estimates can be prevalence based or incidence based. Prevalence-based estimates are the costs for all individuals who have a disease in a specified time period. For example, an estimate of the total number of individuals who currently have asthma, as diagnosed by a physician, reflects the current prevalence of physician-diagnosed asthma. Prevalence-based COI estimates for asthma include all direct and indirect costs associated with the treatment of and the mortality and morbidity effects of asthma within a given time period, such as a year. Prevalence-based COI estimates are a measure of the full financial burden of a disease. They are useful for evaluating the financial benefits of policies aimed at improving the effectiveness of treatment or

1. To avoid omitting the value of productivity for those who are primarily homemakers and don't directly earn a wage, a "shadow" wage equal to that earned by domestic workers in the workforce, or some estimate of the foregone wage based on age and sex, is generally used.

at reducing the morbidity and mortality associated with a disease. This paper focuses on prevalence-based COI estimates for asthma.[2]

In contrast, incidence-based COI estimates reflect expected costs for *new* individuals who develop a disease in a given time period. For example, the number of individuals who receive a *new* diagnosis of asthma from a physician in a year reflects the annual incidence of physician-diagnosed asthma. Incidence-based COI estimates reflect the expected value of direct medical expenditures and lost income and productivity associated with a disease from the time of diagnosis until recovery or death. Because these expenses can occur over an extended time period, incidence-based estimates are usually discounted to the year the illness is diagnosed and expressed in present value terms. Incidence-based COI estimates are useful for evaluating the financial benefit of policies that are aimed at reducing the incidence of new cases of disease.

3. REVIEW OF AVAILABLE ESTIMATES OF NATIONAL COSTS OF ASTHMA

Studies providing estimates of the national costs of asthma in the United States were identified by searching electronic library catalogs, referencing sources cited in press releases on the national costs of asthma, and incorporating references suggested by other researchers. Only studies published after 1985 were used on the assumption that changes in the health care industry probably limit the applicability of earlier studies.

This process identified three studies that estimate the national direct and indirect costs of asthma: Weiss et al. (1992), Smith et al. (1997), and Farquhar et al. (1998a). In addition, U.S. EPA's Cost of Illness handbook (U.S. EPA, 1999) and recently released data from the national Medical Expenditure Panel Survey (AHRQ, 2000) provide information that can be used to develop a national estimate of asthma-related medical costs.

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2. It should be noted that COI estimates are a useful measure of financial burden of disease, but they do not measure the monetary value of the full effect of disease on the welfare of the population and are therefore insufficient for a full cost-benefit analysis of public policies aimed at reducing morbidity or mortality. Willingness to pay (WTP) is the more appropriate measure of the change in welfare in cost-benefit analysis, because it reflects not just the financial effect but also the value people place on the effect on quality of life and longevity. Generally, WTP is expected to exceed COI, but costs paid by third parties (e.g., insurance paid medical costs) will generally not be included in an individual's WTP and should be added to individuals' WTP. Available estimates of WTP for reductions in asthma include Rowe and Chestnut (1986) and Rowe et al. (1984), who report WTP and COI estimates obtained from a panel of asthma patients for reductions in the frequency of asthma episodes; O'Conor and Blomquist (1997), who examine WTP for improved asthma treatment; and Blumenschein and Johannesson (1998), who examine the quality of life impacts of asthma and WTP for an asthma cure. In addition, there is substantial evidence that WTP for reductions in mortality risk far exceed the expected value of lost earnings, which is the COI measure of the financial effect of premature mortality (e.g., Viscusi, 1993).

The Weiss et al. study developed a national cost of asthma estimate for 1985 using asthma-related outcome occurrence and expenditure data from the following sources (years of the data that were averaged are in parentheses):

- American Hospital Association (1985)
- National Ambulatory Medical Care Survey (1985)
- National Health Interview Survey (1983-1987)
- National Hospital Discharge Survey (1983-1987)
- National Medical Care Utilization and Expenditure Survey (1980-1981).

Both the Smith et al. and Farquhar et al. studies developed national cost of asthma estimates for 1987 using the asthma-related outcome occurrence and expenditure data in the 1987 National Medical Expenditure Survey (NMES).[3]

The Weiss et al., Smith et al., and Farquhar et al. estimates are presented in Table 1. These studies included similar cost categories and developed similar annual estimates for direct medical expenditures, with a range across the studies from $2.4 billion to $3.4 billion (mix of 1985 and 1987 dollars). For perspective on the magnitude of the direct medical expenditure estimates for asthma, these values represent roughly 0.5% of the average annual national health care expenditures for 1985-1987 for all causes (HCFA, 2000).

The differences between the Smith et al. and Farquhar et al. results for direct medical costs reflect the inclusion in Farquhar et al. of administrative and other costs estimated using the diagnosis-specific medical expenditure model.[4] This results in a medical cost estimate that is nearly 20% higher, which is plausible given the additional costs included.

A comparison of the Weiss et al. and the Smith et al. direct cost estimates shows the Weiss et al. estimates are lower for hospital and physician services, similar for emergency room visits, and higher for prescription medications. While the NMES data used by Smith et al. include annual expenditures reported by respondents for prescription medicines, the Weiss et al. value is based on an extrapolation from the data on asthma prescription medications being used at the time of the interview by respondents to the 1985 National Ambulatory Medical Care Survey. This extrapolation required assumptions about annual usage and prescription medication costs. As a

3. In addition to the 1987 estimates, Smith et al. reported a total cost estimate of $5.8 billion in 1994 dollars. This reflects an adjustment for price changes, but no adjustment for changes in occurrences. Similarly, Weiss et al. reported total costs of $6.2 billion in 1990 dollars, adjusted only for price changes from 1985 to 1990. These are not emphasized here because they do not account for changes in asthma treatment or frequencies of asthma-related health outcome occurrences.

4. See Farquhar et al. (1998b) for details regarding the diagnosis-specific medical expenditure model.

Table 1
National Costs of Asthma for 1985 and 1987 by Cost Category

Cost Category	Weiss et al. (1992) ($1985 millions)	Smith et al. (1997) ($1987 millions)	Farquhar et al. (1998a) ($1987 millions)
Direct Costs: Medical Expenditures			
Inpatient Hospital	$1,058.8	$1,534.3	not reported
Emergency Room	$200.3	$186.5	not reported
Outpatient Hospital	$129.2	$303.1	not reported
Inpatient Physician [a]	$81.3	not reported	not reported
Outpatient Physician	$193.3	$397.2	not reported
Prescription Medication	$712.7	$498.9	not reported
Total Direct Medical Expenditures	***$2,375.6***	***$2,919.6***	***$3,449.6***
Indirect Costs: Lost Income and Productivity			
Bed Days (age < 5)	not estimated	$14.6	not estimated
Lost School Days (age < 18)	$726.1	$153.6	not estimated
Restricted Activity Days	not estimated	$171.8	not estimated
Lost Employment Days	$284.7	$175.4	$422.9
Lost Housekeeping Days	$406.0	$16.3	$39.3
Asthma Mortality	$676.2	not estimated	$1,026.0
Total Indirect Costs	***$2,093.0***	***$531.7***	***$1,488.3***
Total All Costs	**$4,468.7**	**$3,451.8**	**$4,937.8**

a. Weiss et al. is the only study that reported inpatient physician as a separate category. This cost is probably included as part of inpatient hospital costs in the other studies, but this is not specifically stated by the authors.

result, the difference between the Weiss et al. and Smith et al. prescription medication cost estimates suggests that perhaps Weiss et al. overestimated the actual annual usage or that there are other differences between the samples in the two surveys.

Differences in the indirect cost estimates initially appear to be somewhat greater, with an overall annual range of $0.5 billion to $2.1 billion (mix of 1985 and 1987 dollars). However this difference is greatly reduced if the exclusion of mortality losses in Smith et al. is accounted for. If the average of the mortality cost estimates from Weiss et al. and Farquhar et al. (approximately $850 million) is added to Smith et al., the range of annual indirect costs is narrowed to roughly $1.4 billion to $2.1 billion. Smith et al. and Farquhar et al. report very similar estimates of income and productivity costs for asthma-related morbidity. The Weiss et al. morbidity costs are more than twice as high as those reported by the other two studies. Farquhar et al. include an

income and productivity cost for asthma-related mortality that is somewhat higher than the Weiss et al. estimate.

Including the average of asthma-related mortality costs with the original Smith et al. values narrows the national cost of asthma range for 1985-1987 to $4.3 billion to $4.9 billion. Across the three studies, direct costs represent between 50% and 70% of the total costs, indirect morbidity costs represent between 10% and 30% of total costs, and indirect mortality costs represent between 15% and 20% of the total costs. The Weiss et al. and Smith et al. estimates show that the direct costs are dominated by hospitalization costs (45% to 50%) and prescription medicine costs (20% to 30%). Farquhar et al. did not report results for individual categories of medical costs.

The U.S. EPA study (U.S. EPA, 1999) takes a different approach, reflecting its objective to develop estimates of the lifetime treatment costs for asthma. As a result, instead of providing an estimate of the national costs of asthma, the study provides estimates of the average annual costs for the medical goods and services that are expected to be used in the course of diagnosing and treating asthma over the lifetime of a patient with asthma. Of specific interest, the U.S. EPA study provides cost estimates for the following asthma-related outcomes: hospitalizations, emergency room visits, and physician office visits. The COI estimates for these direct medical expenditure categories are based on approved 1999 Medicare reimbursement levels for the treatment of asthma patients. In addition, the U.S. EPA study provides estimates of the expected annual prescription medication expense for asthma patients in different age groups (those less than 5 years old and all others), and severity classifications based on the typical treatment regimen recommended in the EPR-2 (U.S. Department of Health and Human Services, 1997). Weighting these severity-based costs by the assumed distribution of asthmatics across the severity groups, based on the judgment of a panel of medical experts because other data on asthma severity were not available, provides the expected annual prescription medication expenditure for an "average" asthma patient. While the objective of the U.S. EPA's study was not to develop a national cost of asthma estimate, it is included in this paper because the cost information it provides can be combined with asthma-related outcome occurrence and asthma prevalence data to develop a national estimate of the annual direct costs of asthma.

The Medical Expenditure Panel Survey (MEPS), co-sponsored by the Agency for Healthcare Research and Quality and the National Center for Health Statistics, is a national survey of health care service use, expenditures, and sources of payment (AHRQ, 2000). The MEPS is the third in a series of these national healthcare expenditure surveys, following the National Medical Care Expenditure Survey in 1977 and the National Medical Expenditure Survey (used by Smith et al. and Farquhar et al.) in 1987. Because the MEPS data reflect outcome occurrences and expenditures for 1996, its results require little adjustment to provide updated values for 1997. Therefore, the MEPS results are not presented in this section but in Section 4 where the results from all the studies are updated to their equivalent values for 1997.

To further compare the Weiss et al. and Smith et al. results, and to provide necessary inputs to update the cost estimates to 1997, total cost and asthma-related outcome occurrence information

from the Weiss et al. and Smith et al. studies were used to calculate average costs for the outcomes in the studies' direct cost categories. For example, average costs per hospitalization were calculated by dividing the total cost for hospitalizations by the number of hospitalizations. For all the direct cost category outcomes, except outpatient physician visits, Weiss et al. reported enough information to make these calculations for those younger than 18 years of age and those age 18 and older. For outpatient physician visits, supplemental occurrence data were obtained from Mannino et al. (1998), who reported age-specific outpatient physician visits using the same source of data cited by Weiss et al. Smith et al. did not provide sufficient information to calculate age-specific costs. The average cost results are presented in Table 2 for the direct medical expenditure category outcomes other than prescription medications, which are addressed in Section 4.

Table 2
Average Costs for Asthma-Related Medical Expenditure Outcomes

Study	Age Group	Total Costs in Millions ($year)	Occurrences Reported in the Study	Average Cost per Occurrence ($year)
Inpatient Hospital				
Weiss et al.	age < 18	$250.3 (1985)	160,370	$1,561 (1985)
	age ≥ 18	$808.4 (1985)	303,130	$2,667 (1985)
Smith et al.	all ages	$1,534.3 (1987)	445,000	$3,447 (1987)
Emergency Room				
Weiss et al.	age < 18	$90.4 (1985)	865,180	$104 (1985)
	age ≥ 18	$109.9 (1985)	944,820	$116 (1985)
Smith et al.	all ages	$186.5 (1987)	1,200,000	$155 (1987)
Outpatient Hospital				
Weiss et al.	age < 18	$37.1 (1985)	430,500	$86 (1985)
	age ≥ 18	$92.1 (1985)	1,069,500	$86 (1985)
Smith et al.	all ages	$303.1 (1987)	1,500,000	$202 (1987)
Inpatient Physician				
Weiss et al.	age < 18	$20.2 (1985)	160,370	$126 (1985)
	age ≥ 18	$61.2 (1985)	303,130	$202 (1985)
Smith et al.	not reported			
Outpatient Physician				
Weiss et al.	age < 18	$67.1 (1985)	2,256,900	$30 (1985)
	age ≥ 18	$126.2 (1985)	4,245,100	$30 (1985)
Smith et al.	all ages	$397.2 (1987)	13,000,000	$31 (1987)

This information provides some additional explanation for the differences in the direct medical expenditure estimates presented in Table 1. Clearly, the higher Smith et al. total cost estimates for the inpatient hospital category are the result of higher average cost estimates per

hospitalization, because the studies have similar occurrence estimates. Even if the Weiss et al. costs for inpatient physician services are added, the Smith et al. costs per hospitalization are higher. The higher Smith et al. estimates for the outpatient physician category result from a higher number of asthma-related visits, because the average costs per visit are comparable.

The comparison of the Weiss et al. and Smith et al. results for indirect costs is also assisted by calculating average indirect costs per asthma-related morbidity outcome and per asthma-related mortality. These average costs are presented in Table 3. The number of asthma-related indirect morbidity outcomes are from the National Health Interview Survey (NHIS) for Weiss et al. and from the NMES for Smith et al. A comparison of the indirect costs is complicated by the lack of overlap in the indirect cost categories considered in the studies. However, the results for lost school days, and the sum of lost employment days and lost housekeeping days, are worth noting because the Weiss et al. estimates are higher in both cases, which explains most of the difference in the studies' indirect morbidity cost estimates. Although Smith et al. estimate costs for two additional categories of indirect morbidity costs (bed days for young children and restricted activity days), these do not make up for the substantially higher costs estimated by Weiss et al. in the overlapping categories.

Table 3 shows that the Weiss et al. NHIS-based estimate of the number of asthma-related lost school days is roughly three times larger than the NMES-based estimate in Smith et al. At the same time, Weiss et al. use an average cost per lost school day that is higher than that in Smith et al. In both studies, the value of the time associated with a lost school day is based on the value of the lost earnings or housekeeping services of the primary caregiver. For Weiss et al., the primary caregiver is always assumed to be a woman if earnings information for both the child's mother and father was available. In comparison, the NMES survey identifies the primary caregiver so no assumptions about which earnings to use are necessary. Both studies used estimates of the value of lost household services based on the market value of housekeeping services, but the Weiss et al. estimates of the average value of a lost school day are nearly twice those used by Smith et al. Weiss et al. reference a study by Max et al. (1990) that gives a value of lost housekeeping services for all adults, including those employed outside the home, based on a study of hours spent by men and women doing household tasks.

Weiss et al. list the total costs for lost employment days and lost housekeeping days under the category of "lost work" in their summary tables. In the text they say that there are 3 million days lost from work because of asthma, but it is not clear whether this refers to just lost employment days or lost employment days and lost housekeeping days. However, the average cost per day is not plausible if this is taken to be the number of all lost work days. The alternative is that the 3 million lost days reflects just lost employment days in which case the average cost per lost employment day is $95 and the average cost per lost housekeeping day cannot be calculated because the number of days was not reported.

The Weiss et al. indirect cost estimate for lost housekeeping days is much higher than the Smith et al. estimate, apparently because both the number of days and the cost per day are higher. From the comparison of the value of lost school days, it appears that Weiss et al. used a higher value

Table 3
Average Indirect Costs per Asthma-Related Morbidity and Mortality Outcome

Study	Age Group	Total Costs in Millions ($year)	Occurrences Reported in the Study	Average Cost per Occurrence ($year)
Bed Days				
Weiss et al.	not estimated			
Smith et al.	age < 5	$14.6 (1987)	369,000	$40 (1987)
Lost School Days				
Weiss et al.	age < 18	$726.1 (1985)	10,000,000	$73 (1985)
Smith et al.	age < 18	$153.6 (1987)	3,600,000	$43 (1987)
Restricted Activity Days				
Weiss et al.	not estimated			
Smith et al.	age $ 18	$171.8 (1987)	18,300,000	$9 (1987)
Lost Employment Days				
Weiss et al.	age $ 18	$284.7 (1985)	3,000,000	$95 (1985)
Smith et al.	age $ 18	$175.4 (1987)	2,100,000	$84 (1987)
Lost Housekeeping Days				
Weiss et al.[a]	age $ 18	$406.0 (1985)	not reported	
Smith et al.	age $ 18	$16.3 (1987)	769,000	$21 (1987)
Asthma-Related Mortalities				
Weiss et al.[b]	age < 18	$99.0 (1985)	172	$574,911 (1985)
	age $ 18	$577.3 (1985)	3,708	$155,699 (1985)
Smith et al.	not estimated			

a. Weiss et al. included asthma-related bed days and a share of asthma-related restricted activity days as lost housekeeping days, but they did not report the total number of lost housekeeping days that they used in their calculations.

b. Age-specific asthma-related mortalities were calculated from the age distribution information for asthma mortalities reported for 1984-1986 by Mannino et al. (1998) combined with reported total number of asthma-related mortalities for 1985 from Weiss et al.

for lost housekeeping services, but the apparent difference from the lost school days results is not great enough to account for the difference in the cost estimate for lost housekeeping days. Weiss et al. say they include a share of restricted activity days in the lost housekeeping category, which Smith et al. address as a separate outcome category, but at a fairly low cost per day. When these two categories from the Smith et al. estimates are summed, the total is about $188 million, which is less than half of the Weiss et al. estimate for lost housekeeping days. It is hard to say, based on the information reported, whether this difference is due to a higher estimate of the number of lost days, a higher cost per day, or both.

4. UPDATING THE NATIONAL COSTS OF ASTHMA TO 1997

Estimates of the national direct costs of asthma for 1997 based on the information in Weiss et al., the U.S. EPA study, and the MEPS were developed as follows:

1. Three sets of average costs per outcome (e.g., emergency room visit) were calculated based on the information reported by Weiss et al. (see Table 2), U.S. EPA (1999), and the MEPS.

2. Average costs per outcome were adjusted to 1997 dollars using medical price indices (U.S. Bureau of Labor Statistics, 2000). An additional adjustment for inpatient hospitalizations and inpatient physician services was incorporated into the Weiss et al. costs to account for changes in the average length of an asthma-related hospital stay since the time of the original study data.

3. Average annual asthma-related outcome occurrences were obtained for 1996 and 1997 from data sources comparable to those used by Weiss et al. Occurrences for 1996 were also obtained from the MEPS.

4. The updated average costs per outcome were multiplied by the average asthma-related outcome occurrences to produce national direct costs of asthma estimates for 1997.

The MEPS data allow for the calculation of the number of asthma-related outcome occurrences and associated expenditures for treatment in the direct cost categories for 1996. The number of occurrences estimated from the MEPS data is not adjusted further because there is no comparable survey data from 1997 from which an average annual number of occurrences for 1996-1997 can be estimated. However, the estimated expenditures for these occurrences are updated from 1996 to 1997 dollars using the same price indices that are applied to the Weiss et al. and U.S. EPA study values. Because the MEPS represents the followup survey to the NMES, which provided the cost and occurrence information for the Smith et al. estimates, the 1997 estimates based on the MEPS can be considered an update of the Smith et al. estimates.

The Farquhar et al. study was not updated using these steps because the study included its own update to 1996, which accounts for changes in the prices of medical goods and services and in the number of asthma-related outcome occurrences. Therefore, the Farquhar et al. estimate for 1996 is reported directly for comparison to the 1997 estimates based on the other two studies and the MEPS data, while recognizing that slight changes would most likely result if the 1996 Farquhar et al. results were revised to account for changes in prices from 1996 to 1997.

Indirect costs for asthma-related morbidity outcomes for Weiss et al. and Smith et al. were updated to 1997 by multiplying the original study estimates by the rate of growth in the number of people with diagnosed asthma and the average weekly earnings price index (U.S. Bureau of Labor Statistics, 2000). This assumes that the average number of occurrences of these asthma-related outcomes has remained constant per asthmatic. If changes in asthma treatments have

reduced symptom frequencies and severity, then these occurrences may be somewhat overstated. This simplifying assumption was used, however, because ambiguities in the calculations of per occurrence costs (see Section 3) meant that the only other alternative was to obtain new original data for all of these outcomes. This was beyond the scope of this effort.

Indirect costs for asthma-related mortality were updated to 1997 using the average number of asthma-related deaths from 1996 and 1997 (NCHS, 2000), and applying the inflation adjusted costs per premature mortality from Weiss et al.

4.1 Direct Costs: 1997 Values

Five alternative estimates of total direct costs for asthma in 1997 are presented in this section. Average costs per asthma-related occurrence were obtained from three alternative sources: Weiss et al. average costs updated to 1997 dollars, MEPS average expenditure estimates updated to 1997 dollars, and U.S. EPA average costs adjusted to 1997 dollars. Two alternative sources of estimates of the number of asthma-related outcome occurrences are used: updates based on 1996-1997 data using sources comparable to those used by Weiss et al., and estimates for 1996 from the MEPS. In addition, Farquhar et al. provide their own update to 1996 dollars and occurrences, which is included here for comparison.

The alternative estimates are presented and compared. A range of "best" estimates is selected from the estimates presented based on an evaluation of the underlying data sources and the updating assumptions.

Average Direct Costs per Asthma-Related Outcome: 1997

The estimated average costs per asthma-related outcome in Table 2 for Weiss et al. were adjusted, along with the per-outcome costs from the U.S. EPA study and the MEPS expenditure estimates, to their 1997 equivalents using various medical price indices (U.S. Bureau of Labor Statistics, 2000). In addition to accounting for price inflation, the average cost estimates for inpatient hospitalizations and inpatient physician treatment for Weiss et al. were adjusted to account for reductions in the average length of stay for an asthma-related hospitalization between 1985 and 1997.

Weiss et al. report an average length of stay of 5.0 days for an asthma-related hospitalization. The average length of stay for an asthma-related hospitalization based on data from the 1996 and 1997 National Hospital Discharge Surveys was 3.5 days. Therefore the Weiss et al. inpatient costs were adjusted by multiplying the updated 1997 estimates by 70% (3.5/5.0).

The resulting average costs per asthma-related outcome for the direct medical expenditure categories that were used to develop the 1997 national cost of asthma estimates are presented in Table 4. In general, average costs per occurrence are comparable or lower for asthma patients

Table 4
Updated Average Costs for Direct Medical Expenditure Outcomes ($1997)

Source	Age Group	Average Cost per Occurrence ($1997)	U.S. BLS Price Adjustment Index
Inpatient Hospital			
Updated Weiss et al.	age < 18	$2,620	Hospital and Related Services
	age ≥ 18	$4,476	
U.S. EPA	age < 18	$2,892	
	age ≥ 18	$2,462	
MEPS	age < 18	$2,027	
	age ≥ 18	$5,525	
Emergency Room			
Updated Weiss et al.	age < 18	$251	Hospital and Related Services
	age ≥ 18	$279	
U.S. EPA	all ages	$412	
MEPS	age < 18	$177	
	age ≥ 18	$421	
Outpatient Hospital			
Updated Weiss et al.	age < 18	$207	Hospital and Related Services[a]
	age ≥ 18	$207	
U.S. EPA	not estimated		Outpatient Hospital Services
MEPS	age < 18	$176	
	age ≥ 18	$285	
Inpatient Physician			
Updated Weiss et al.	age < 18	$248	Physicians' Services
	age ≥ 18	$397	
U.S. EPA	not estimated		
MEPS	age < 18	$214	
	age ≥ 18	$527	
Outpatient Physician			
Updated Weiss et al.	age < 18	$58	Physicians' Services
	age ≥ 18	$58	
U.S. EPA	all ages	$175	
MEPS	age < 18	$50	
	age ≥ 18	$67	

a. The Outpatient Hospital Services Index was not used for the Weiss et al. estimates because the index starts in 1986. The two indices have nearly identical values for the change in prices from 1986 to 1997, so the Hospital and Related Services index was used for the Weiss et al. estimates to account for the full time period.

under 18 years old. The MEPS data tend to be lower than the updated Weiss et al. estimates for those under 18 and higher for those 18 and over. Thus, the MEPS estimates show greater differences by age. The U.S. EPA estimates are lower for inpatient hospitalizations and higher for emergency room visits and for outpatient physician visits. U.S. EPA's outpatient physician costs per outcome are roughly three times the estimates from Weiss et al. or the MEPS (see Table 4). One source for this potential discrepancy is that the U.S. EPA costs are based on Medicare's allowable services and charges for followup care provided to asthma patients in a physician's office. It is possible, therefore, that the difference is the result of potentially higher allowable costs for Medicare than average, or because the full range of allowable followup services is rarely used on each visit.

Average annual prescription medication expenditures per asthmatic were calculated from the information in the Weiss et al. and Smith et al. studies by taking the reported total prescription medication expenditures and dividing by the estimated number of people with diagnosed asthma for the respective study period as reported in Mannino et al. (1998). This approach produced average annual prescription medication cost estimates per asthmatic of $81 (1985 dollars) and $49 (1987 dollars) for the Weiss et al. and Smith et al. studies, respectively. The problem with updating these values by simply accounting for price inflation (which would produce expected average annual expenditures of $169 and $87, respectively, in 1997 dollars) is that it assumes the only change with regard to prescription medications for asthma has been in the price. This overlooks the fact that the use of prescription medications for asthma has undergone significant changes since the mid-1980s with the introduction of new medications, increased emphasis on regular use of medications to control underlying symptoms, and the development and distribution of recommended medication treatment regimens such as in the EPR-2.

Annual national prescription medication costs for asthma for 1996 were obtained from the prescription medication expenditure data component of the MEPS. After checking to ensure that prescription medication payments having a first-listed diagnosis code for asthma were used primarily for the treatment of asthma, payments were extracted separately for those younger than 18 years of age and those age 18 and older. These age-group estimates were then divided by the average number of people with asthma in those age groups to obtain average prescription medication cost estimates per asthmatic. (See Section 4.2 for a discussion of the source of data for asthma prevalence.)

The U.S. EPA study's prescription medication cost estimates were already reported on a per asthmatic basis with separate estimates for each of the age and severity group combinations based on the EPR-2 recommended treatment protocols. Weighting the costs to develop an average cost per asthma patient required incorporating the percentages of the asthmatic population assumed by the U.S. EPA to fall into each of the following categories (percentages are in parenthesis): mild intermittent (35%), mild persistent (35%), moderate (25%), and severe (5%). For example, the following expected annual prescription medication costs (in 1999 dollars) for a person with asthma (age 5 or older) in each severity category are as follows: mild intermittent ($25), mild persistent ($284), moderate ($1,440), and severe ($4,160). Multiplying the average costs for a severity class by its percentage of the total asthmatic population and then

summing across all severity classes produces an expected annual prescription medication expense for an average person with asthma over age 5 of $676 (1999 dollars).

The average prescription medication costs per asthmatic based on the MEPS and on the U.S. EPA report were then adjusted for price inflation to 1997 dollars using the Prescription Drugs and Medical Supplies price index (U.S. Bureau of Labor Statistics, 2000). The results are shown in Table 5.

Table 5
Annual Prescription Medication Costs per Person with Asthma ($1997)

Source	Age Group	Average Annual Medication Prescription Cost per Person with Asthma
1996 Medical Expenditure Panel Survey	Age < 18	$103
	Age $ 18	$203
U.S. EPA, 1999	Age < 5	$430
	Age $ 5	$617

An age-weighted average annual cost of prescription medications for a person with asthma based on the MEPS data is $170 (1997 dollars). This is about double what would have been obtained from simply inflating the 1987 NMES based estimate from Smith et al. to 1997 dollars to account for changes in the price of prescription medications. Since the MEPS and NMES surveys obtain comparable information, this comparison suggests that changes in asthma medication usage have doubled (in real dollars) the per asthmatic costs of prescription medicines between 1987 and 1997.

Table 5 reports a dramatic difference in the annual prescription medication costs per asthmatic depending on the source of the estimate, with the U.S. EPA study's estimates being much higher than those from the MEPS. There are two potential reasons for this difference. First, as the U.S. EPA study recognizes, the recommended treatment regimen is unlikely to be used by all people with asthma, either because they are not prescribed the recommended regimen by their physicians or because they do not follow the prescribed regimen they are given. The U.S. EPA report acknowledges this possibility, but argues that failing to receive and/or follow an optimal medication treatment regimen would most likely affect only the mix of medications a person with asthma uses (fewer long-term management medications and more short-term medications to address exacerbations), not overall expenditures (U.S. EPA, 1999). The results in Table 5 suggest an alternative conclusion that failure to receive or follow an optimal medication treatment regimen reduces the prescription medication expenditures per asthmatic.

A second potential explanation for the observed difference in the prescription medication costs is that the assumed distribution of asthma severity in the U.S. EPA study may be incorrect. Because

there are no national data to determine the distribution of asthma severity, the distribution used in the U.S. EPA study reflects a modified version of the conclusion of an expert panel of physicians assembled in 1991.[5] If the assumed distribution of asthmatics in the moderate and severe groups is in fact too high, the average prescription medication costs per asthmatic would be overstated.

The MEPS cost data represent the best readily available empirical information on the actual current use of prescription medications to treat asthma, because they are based on a national probability survey collecting data on actual medical expenditures. The U.S. EPA estimates, on the other hand, are based on a few key assumptions that we cannot verify as accurate or not. For this paper, therefore, we use the MEPS data, adjusted to 1997 dollars, as the basis for the estimate of prescription medication costs for the updated asthma costs based on the Weiss et al. study.

Asthma-Related Outcome Occurrences: 1997

For all of the direct medical expenditure categories (see Table 2), data sources comparable to the ones used in the Weiss et al. study were available. Where possible, asthma-related outcome occurrence information for 1996 and 1997 was averaged for use in developing the 1997 national cost of asthma estimates to preserve trends while providing a control against results being overly influenced by sampling errors and/or anomalies that could exist within the data from a single year. These updated occurrence data were also used to develop national cost of asthma estimates for 1997 using the average cost per occurrence estimates from the U.S. EPA study and from the MEPS. In addition, the MEPS provides estimates of asthma-related outcome occurrences for 1996.

The 1996-1997 asthma-related outcome occurrence and asthma prevalence estimates used to calculate national cost of asthma estimates for 1997 are presented in Table 6. In addition, the occurrence estimates for these outcomes available from the MEPS data are presented for comparison.

Table 6 shows that there is considerable variability in the outcomes estimates from the different data sources. The MEPS provides much lower estimates of the number of asthma-related hospitalizations for those under younger than 18 years of age and for asthma-related emergency room and outpatient hospital visits for both age groups compared to the alternative sources. At the same time, the MEPS provides a much larger estimate of the number of asthma-related outpatient physician (office) visits than the NAMCS. Hospitalizations and emergency room visits for asthma are fairly infrequent occurrences in the MEPS sample, which is a national probability sample of the general population. National estimates of occurrences are calculated using the

5. When the expert panel met in 1991, there were only three recognized severity classes for asthmatics: mild, moderate, and severe. The EPR-2 creates four severity classes, essentially splitting the mild category into mild-intermittent and mild-persistent. In the modification, the percentage of asthmatics the panel assigned to the mild category (70%) was allocated evenly between the two new mild classifications, and the assumed distributions for the moderate (25%) and severe (5%) classes were not adjusted.

Table 6
Asthma-Related Occurrence Estimates for 1996-1997

Outcome Category	Annual Occurrences by Age			Source
	Age < 5	Age < 18	Age $ 18	
Hospital admissions		219,348	259,204	1996-1997 NHDS
		101,472	276,980	1996 MEPS
Emergency room visits[a]		783,465	1,142,514	1996-1997 NHAMCS
		515,123	394,781	1996 MEPS
Outpatient Hospital		435,404	564,516	1996-1997 NHAMCS
		278,673	263,610	1996 MEPS
Outpatient physician		3,559,158	5,883,398	1996-1997 NAMCS
		5,321,018	8,554,642	1996 MEPS
Asthma mortality		228	5,323	1996-1997 NCHS
Self-reported asthmatics	1,016,146	4,861,866	9,875,001	1995-1996 NHIS

a. The Weiss et al. study assumes an emergency room visit precedes each hospitalization, so the number of asthma-related inpatient hospitalizations are added to the number of directly estimated emergency room visits to develop a total number of emergency room visits. To maintain consistency with the original study, this approach was maintained for the Weiss et al. update. For the MEPS and the U.S. EPA 1997 national cost of asthma estimates, only the number of directly estimated asthma-related emergency room visits is used.

MEPS = Medical Expenditure Panel Survey.
NAMCS = National Ambulatory Care Medical Survey.
NCHS = National Center for Health Statistics.
NHAMCS = National Hospital Ambulatory Medical Care Survey.
NHDS = National Hospital Discharge Survey.
NHIS = National Health Interview Survey.

population weights for each person in the sample. For fairly rare occurrences this means that the extrapolation to national estimates may be fairly uncertain. On the other hand, the institution-based surveys (NHDS and NHAMCS) sample a significant share of the hospitalizations and emergency room visits that occur nationwide. Thus, there may be reason to expect greater accuracy in the national estimates based on the NHDS and NHAMCS for the relatively rare asthma-related hospitalizations and emergency room visits.

It is not so clear that the MEPS or the NACMS would have particular advantages for estimating national counts of asthma-related outpatient physician visits. There could be differences in sampling or in the way the purpose of the visit is determined. It is notable that asthma-related outpatient physician visits were also much higher in the Smith et al. study (based on the predecessor survey to the MEPS) than in the Weiss et al. study (based on the earlier NAMCS). Smith et al. report an estimate of 13 million asthma-related outpatient physician visits in 1987, while Weiss et al. report about 6.5 million visits for 1985.

Direct Costs of Asthma for 1997

Table 7 presents five alternative estimates of the direct costs of asthma for 1997. There are four combinations of the costs per occurrence and occurrence estimates plus the update provided by Farquhar et al. for 1996. The four combinations are

< updates of the costs reported by Weiss et al. and occurrences from comparable data sources to those used by Weiss et al.

< costs from the MEPS and occurrences from comparable data sources to those used by Weiss et al.

< costs and occurrences from the MEPS

< costs from the U.S. EPA study and occurrences from comparable data sources to those used by Weiss et al.

Table 7
National Direct Costs of Asthma Estimates ($1997 millions)

Age Category	Direct Medical Expenditure Category						
	Inpatient Hospital	Emergency Room Visits	Outpatient Hospital	Inpatient Physician	Outpatient Physician	Prescription Medications	Total
Weiss et al. Updated Cost and Occurrence Estimates							
Age < 18	$575	$251	$90	$38	$208	$500	**$1,662**
Age ≥ 18	$1,160	$391	$117	$72	$344	$2,003	**$4,087**
All Ages	$1,735	$642	$207	$110	$552	$2,503	**$5,749**
MEPS Cost and Weiss et al. Updated Occurrence Estimates							
Age < 18	$445	$138	$77	$47	$177	$500	**$1,383**
Age ≥ 18	$1,432	$481	$161	$137	$396	$2,003	**$4,610**
All Ages	$1,877	$620	$238	$183	$573	$2,503	**$5,993**
MEPS Cost and Occurrence Estimates							
Age < 18	$206	$91	$49	$22	$264	$500	**$1,132**
Age ≥ 18	$1,530	$166	$75	$146	$576	$2,003	**$4,496**
All Ages	$1,736	$257	$124	$168	$840	$2,503	**$5,628**
U.S. EPA Cost and Weiss et al. Updated Occurrence Estimates							
Age < 18	$634	$323	not estimated	not estimated	$625	$2,809	**$4,391**
Age ≥ 18	$638	$470			$1,032	$6,092	**$8,233**
All Ages	$1,273	$793			$1,657	$8,901	**$12,624**
Update from Farquhar et al. (1996 millions)							
All Ages	not provided						**$12,004**

The total direct cost estimates in Table 7 range from $5.6 billion to $12.6 billion, but after evaluating the credibility of all of the estimates, a more reasonable range is $5.6 billion to $6.2 billion.

As previously discussed, the difference between U.S. EPA's estimate of prescription medication expenses and the MEPS-based results can potentially be attributed to the U.S. EPA's "bottom up" approach to estimating these expenses based on recommended treatment regimens. The resulting differences in Table 7 for prescription medications are therefore not surprising. If the MEPS data are an accurate reflection of actual prescription costs for asthma, then the estimates based on the U.S. EPA prescription cost estimates overstate actual asthma-related prescription medication expenditures. This is because either the optimal prescription medication protocols are not being followed by all people with asthma or the U.S. EPA's estimates of the shares in the moderate and severe asthma categories are not accurate. Adjusting the U.S. EPA direct cost estimate by adopting the MEPS prescription medications estimate results in a direct medical expenditures estimate of $6.2 billion for the U.S. EPA study, which places it much closer to the estimates based on the MEPS and the updated Weiss et al. estimates.

An examination of the data interpretations and assumptions used in the Farquhar et al. update of their estimates from 1987 to 1996 raises questions that suggest less emphasis should be given to the updated results from this study. For example, Farquhar et al. report that their initial direct cost estimate of $3.4 billion (1987 dollars) was inflated by an annual medical price inflation factor of 7.4% to obtain an updated direct costs estimate of $7.8 billion (1996 dollars) (before accounting for increases in occurrences). However, to replicate their result, we estimate that the annual inflation rate would have to be 9.5%. Alternatively, when their 1987 direct cost estimate is inflated according to the increase in the medical consumer price index from 1987 (130.1) to 1996 (228.2), the resulting updated estimate is $6.1 billion (1996 dollars). While price indices for various medical services did increase at a rate higher than the general medical services price index over this period (e.g., the hospital and related services index), each index is applied to only a component of the costs, and none of the ones used in the procedure presented in this paper would account for the observed difference in the updated costs and the estimate generated by using the general medical services price index.

A second example of assumptions made by Farquhar et al. that cannot be verified is their adjustment factor for the increase in asthma-related hospitalizations. They report using a 5% annual rate of increase in hospitalizations to estimate hospitalizations in 1996, citing data from the National Hospital Discharge Survey for 1987 to 1993 reported by Mannino et al. (1998). We found, on the other hand, that these data show no increase in asthma-related hospitalizations over the entire period from 1987 to 1996, and a decline in total admissions for the period cited by Farquhar et al. It is important to note that these concerns apply only to the updated Farquhar et al. estimates for direct medical expenditures. The original estimate of direct medical expenditures for 1987 seems reasonable, because it was just 20% higher than the Smith et al. direct cost estimates.

If the more problematic estimates in Table 7 are disregarded, the range of total direct costs is from $5.6 billion to $6.2 billion. This leaves out the Farquhar et al. updated estimates that do not appear to be consistent with the data that they cite, and replaces the U.S. EPA's prescription medicine cost estimate with the prescription medicine cost estimate from the MEPS. Even using this lower prescription medicine cost estimate, prescription medicines represent nearly 45% of the total direct costs of asthma. The second largest cost category is hospitalizations, which represent about 30% of the total direct costs. Next are emergency room visits and outpatient physician visits, which each represent about 10% of total direct costs. This contrasts with the mid-1980s when hospitalizations represented nearly half of the direct costs and prescription medicines were 30% or less.

4.2 Indirect Costs: 1997 Estimates

For indirect morbidity costs, the percentage change in the number of people who say they have asthma, as measured in the NHIS, from the study's baseline year to the average from 1995 and 1996 was used to update the number of asthma-related outcome occurrences for the Weiss et al. and Smith et al. studies to 1997. Asthma prevalence estimates from the NHIS for 1997 were not used because changes in the 1997 survey questions concerning asthma prevalence effectively identify a different population of people with asthma than in earlier surveys. In the 1997 NHIS, three asthma-related questions were asked (NCHS, 1999):

1. Have you ever been told by a doctor or other health professional that you had asthma?
2. During the past 12 months, have you had an episode of asthma or an asthma attack?
3. During the past 12 months, have you had to visit an emergency room or urgent care center because of asthma?

These questions are different from the earlier NHIS question used to determine the number of people with asthma (personal communication, A. Hardy, NCHS, 2000), which asked:

> During the past 12 months did anyone in the family have asthma?

The first question in the 1997 NHIS clearly can include individuals who no longer have asthma or who are not actively experiencing symptoms or taking treatments. The subsequent 1997 questions define a more narrow subset of asthmatics who have had episodic symptoms within the past 12 months. Combined, this set of questions appears to potentially exclude those who have their asthma under control but are still receiving treatment. The prevalence estimates from these questions reflect this. Whereas the average number of self-reported asthmatics estimated from the 1995 and 1996 NHIS was roughly 14.7 million, the responses to the first 1997 question indicate roughly 25.7 million people had ever been diagnosed with asthma and the second question results provide an estimate of roughly 11.1 million people who had experienced an asthma episode in the past year. For updated occurrence estimates based on the increase in the prevalence of asthma over time, it is important to have a consistent series of data. As a result, growth in the age-group-specific number of people with asthma was calculated using the average

of the 1995 and 1996 NHIS responses. This probably slightly understates the rate of growth to 1997.

Overall, the number of self-reported asthmatics increased by about 50% from 1987 to 1995-1996 and by about 70% from 1985 to 1996-1997. Therefore the number of the indirect morbidity outcomes was assumed to increase by 70% and 50% for the Weiss et al. and the Smith et al. studies, respectively. As previously mentioned, this process implicitly assumes that the per-asthmatic rate for these outcomes has remained unchanged.

The indirect mortality costs estimated by Weiss et al. were updated by calculating the average cost per mortality (for those under 18 years of age and those age 18 and older) from the Weiss et al. results, updating the average cost to 1997 dollars using the wage inflation index, and applying the updated average costs to the number of asthma-related deaths in each age group as reported by the NCHS. The number of deaths were averaged for 1996 and 1997 for each age group.

The resulting updated estimates for indirect costs of asthma as a result of asthma-related morbidity and mortality are shown in Table 8. The main differences in the indirect costs between the Weiss et al. and the Smith et al. updates are the estimation of asthma-related mortality costs by Weiss et al. and the significantly higher costs estimated by Weiss et al. for lost school days and lost housekeeping days. The value of lost income and productivity from asthma-related mortalities can be added to the Smith et al. indirect cost estimates without introducing double-counting. This brings the Smith et al. estimate to $2.4 billion.

Table 8
National Indirect Costs of Asthma Estimates ($1997 millions)

Cost Category	Update of Weiss et al. (1992)	Update of Smith et al. (1997)	Farquhar et al. (1998a) ($1996 millions)
Bed Days (age < 5)	not estimated	$33	individual category estimates not provided
Lost School Days (age < 18)	$1,784	$314	
Restricted Activity Days	not estimated	$331	
Lost Employment Days	$671	$338	
Lost Housekeeping Days	$957	$37	
Asthma Mortality	$1,363	not estimated	
Total Indirect Costs	***$4,776***	***$1,052***	***$1,994***

Table 8 also shows the 1996 estimate of indirect costs reported by Farquhar et al. They give very little explanation of how these indirect costs were updated, but the original 1987 estimate included morbidity and mortality costs. However, the indirect cost estimate grew only about 33% from the 1987 estimate, while the updates of the Weiss et al. and Smith et al. estimates resulted in a doubling of the values. Less weight is therefore given to the Farquhar et al. estimate for

1996. It does not appear to adequately reflect inflation and the growth in the prevalence of asthma from 1987 to 1997.

4.3 1997 National Costs of Asthma

Table 9 presents the "best" estimates of the annual direct and indirect costs of asthma for 1997. The "low" indirect cost estimate represents the sum of the updated indirect mortality costs from Weiss et al. and the updated indirect morbidity costs from Smith et al. The "high" indirect cost estimate reflects the sum of the updated indirect mortality costs and the updated indirect morbidity costs from Weiss et al. The results show a range of $8 billion to $11 billion annual total costs of asthma in 1997. Direct costs represent between 55% and 70% of the total costs.

Table 9
1997 National Costs of Asthma: Best Estimates

Source of Direct Costs	Direct Costs ($1997 millions)	Indirect Costs ($1997 millions)	Total Costs ($1997 millions)
Updated Weiss et al.	$5,749	low: $2,415	low: $8,165
		high: $4,776	high: $10,525
MEPS costs and updated Weiss et al. occurrences	$5,993	low: $2,415	low: $8,408
		high: $4,776	high: $10,769
MEPS costs and occurrences	$5,628	low: $2,415	low: $8,043
		high: $4,776	high: $10,404
U.S. EPA costs (except medicines) and Weiss et al. updated occurrences	$6,226	low: $2,415	low: $8,641
		high: $4,776	high: $11,002

Distribution of Costs by Age

An additional area of the results that is worth noting is the distribution of the costs by age group. This information for the updated Weiss et al., the MEPS/updated Smith et al., and the U.S. EPA-based results is presented in Table 10.

With the exception of the MEPS-based results, these estimates are roughly consistent with the estimate from the NHIS that 33% of the population with asthma is less than 18 years old. This consistency suggests that annual total costs per asthmatic do not vary much by age. However, because those less than 18 years old represent only 26% of the 1997 U.S. population (U.S. Bureau of the Census, 1998), asthma costs are disproportionately associated with those under 18 years old. This results from the higher prevalence of asthma in the under 18 population.

Table 10
Distribution of 1997 National Costs of Asthma by Age

Study	Direct Costs		Indirect Costs	
	Age < 18	Age $ 18	Age < 18	Age $ 18
Updated Weiss et al.	29%	71%	41%	59%
MEPS/updated Smith et al.[a]	20%	80%	22%	78%
U.S. EPA	35%	65%	n/a	n/a

a. This row reflects the MEPS-based direct cost estimates, the updated Smith et al. morbidity indirect cost estimates, and the updated Weiss et al. mortality indirect cost estimates.

Trends in Asthma Prevalence and Costs

To place the 1997 national cost of asthma estimates in perspective, Table 11 presents the percentage increases in asthma prevalence and selected asthma-related outcomes between the 1984-1986 period and the 1996-1997 period along with the percentage change in the U.S. population.

Table 11
Change in Asthma Related Occurrences (1984-1986 to 1996-1997)

Asthma-Related Outcome	Data Source	Time Period Considered	Percentage Change in Outcome
U.S. Population	U.S. Census Bureau	1984-86 to 1996-97	12%
Asthma Prevalence	NHIS	1984-86 to 1995-96	68%
Asthma Mortality	NCHS	1984-86 to 1996-97	43%
Physician Visits	NAMCS	1984-86 to 1996-97	45%
	NMES and MEPS	1987 to 1996	7%
Emergency Room Visits	NHAMCS	1984-86 to 1996-97	43%
	NMES and MEPS	1987 to 1996	-24%
Hospital Admissions	NHDS	1984-86 to 1996-97	3%
	NMES and MEPS	1987 to 1996	-15%
Outpatient Hospital Visits	NHAMCS	1984-86 to 1996-97	-33%
	NMES and MEPS	1987 to 1996	-64%
Average Hospital Length of Stay	Weiss et al, NHDS	1984-86 to 1996-97	-30%

MEPS = Medical Expenditure Panel Survey.
NAMCS = National Ambulatory Care Medical Survey.
NCHS = National Center for Health Statistics.
NHAMCS = National Hospital Ambulatory Medical Care Survey.
NHDS = National Hospital Discharge Survey.
NHIS = National Health Interview Survey.

Table 11 shows that while the U.S. population increased roughly 12% between 1984-1986 and 1996-1997, asthma prevalence, as estimated from NHIS data, increased by about 70%. This increase beyond the population growth rate indicates an alarming increase in asthma prevalence in the United States, and is one of the main reasons for mounting concern about asthma prevention and management in the public health arena. During this same time period, asthma-related mortality increased by about 45%. While this represents a significant increase in the absolute number of asthma-related deaths, it also implies that, on a per-asthmatic basis, asthma-related deaths are occurring less frequently now than in the past.

Of the remaining outcomes in Table 11, the most consistent result is seen for asthma-related hospitalizations, which, depending on the data source, either remained nearly constant from the mid-1980s until 1996-1997 or declined by 15%. Regardless of source of data under consideration, compared to the nearly 70% increase in asthma prevalence, this represents a significant decrease in the per-asthmatic hospitalization rate. In addition, as previously discussed, the average length of stay for an asthma-related hospitalization decreased since the mid-1980s by roughly 30%. Combined, these results suggest significantly fewer hospital resources were being allocated to the treatment of asthma in 1997 compared to in the mid-1980s. This result is consistent with the stated goal of such initiatives as the EPR-2 (U.S. Department of Health and Human Services, 1997), which seek to shift treatment for asthma out of the hospital and emergency room and into physicians' offices representing an effort to increase prevention of asthma exacerbation. However, attributing this result solely to changes in asthma-related treatment patterns is likely to overstate their current impact because the growth of managed care in this period also introduced numerous incentives to avoid providing or receiving hospital-based care, and because asthma-related mortality has not shown a similar improvement.

The difference in estimates of the percentage change for asthma-related hospitalizations points to the sensitivity of the results to the source of the data. This result is brought out most clearly with the emergency room visit results, where the magnitudes of the changes under both the alternative data source options are large, but the changes have opposite signs. Relying on the NHAMCS data, one could conclude that while over time emergency room visits have increased in absolute numbers, there is some evidence of improved use of this medical resource because the increase has not kept pace with increase in the asthma prevalence. Relying on the NMES-MEPS data, the conclusion that significant improvement has occurred would be made much more forcefully given that the occurrence estimates show an absolute decline in the use of the resource while at the same time there has been a sharp increase in prevalence.

5. DISTRIBUTION OF DIRECT COSTS ACROSS SOURCES OF PAYMENT

Of the studies directly presenting national cost of asthma estimates, only Farquhar et al. developed estimates of how the direct costs of asthma are distributed among various potential payer groups. While questions have been raised about the updated costs of asthma presented for

1996 in the Farquhar et al. paper, there is no grounds for questioning the payer distribution information presented in the study. In addition, the MEPS contains information that allocates total payments for treatments and procedures across payer groups within each outcome category. The payment distribution information for the total direct costs of asthma from Farquhar et al. and from the MEPS data is presented in Table 12, alongside similar estimates from the Health Care Financing Agency for the estimated national medical care expenditures for physician and hospital services and prescription medications in 1997 (HCFA, undated).

Table 12
Distribution of Direct Medical Care Costs by Sources of Payment

Sources of Payment	Asthma-Specific Payment Distribution Estimates		All Medical Care Payment Distribution Estimates[a] (HCFA, undated)
	(Farquhar et al., 1998a)	MEPS	
Out of pocket	26%	23%	10%
Private insurance	37%	41%	39%
Medicare	12%	21%	25%
Medicaid	15%	12%	13%
Other federal	8%	0%	4%
Other state	0%	0%	2%
Worker's compensation	0%	0%	2%
Other	2%	3%	3%

a. These estimates are limited to physician and hospital services and prescription medication. Care categories such as nursing home care that do not include any asthma costs are excluded.

The information in Table 12 shows that, relative to general medical care, the financial burden of medical care for asthma falls to a greater extent on asthma patients and their families. While out-of-pocket expenses represent about 25% of the medical expenditures for asthma, they represent only 10% of all expenditures for physician and hospital services and for prescription medication in the United States. This difference is largely accounted for by the differences in expenses covered by Medicare and other federal programs. This is probably because of the heavy reliance on prescription medications in the treatment of asthma combined with Medicare's general lack of coverage for prescription medications (Medicare, 2000). For example, while more than 40% of the estimated direct costs of asthma are accounted for by prescription medications, MEPS information shows that Medicare provides payment for less than 1% of the estimated asthma-related prescription medication expenditures for individuals of all ages (results not shown). Also, the age distribution for asthma patients is younger than for many other illness, so their expenses may be less likely to be covered by Medicare.

6. CONCLUSIONS

The initial intent of this paper was to conduct a literature review of the costs of asthma, but available studies were based on data from the mid-1980s. With significant changes in asthma prevalence and in asthma treatment in the last decade, it was clear that the available estimates needed to be updated by more than simple inflation factors. Readily available data from the mid-1990s on the usage of asthma-related health care services (e.g., hospitalizations, emergency room visits), asthma-related mortality, and the number of individuals with asthma were combined with inflation-adjusted costs from the available literature to update the national cost of asthma estimates to 1997. The updates show that the annual costs of asthma in the United States are most likely between $8 billion and $11 billion (in 1997 dollars and based on 1995-1997 data). This represents about double the estimates from the mid-1980s, which were between $4.5 and $5.0 billion.[6] Accounting for a doubling in the general medical price index, and an almost 70% increase in asthma prevalence over this period, means that the average costs per asthmatic decreased, in real terms, over this period.

The allocation of asthma costs across categories shows about 55% to 70% of the total costs are for direct medical expenditures, about 15% to 30% are for indirect morbidity costs, and about 15% are for indirect mortality costs. The indirect costs represent the market value of lost productivity (e.g., lost wages) due to asthma-related illness and premature mortality.

Roughly one-third of the total costs of asthma are for children under 18 years old. This is consistent with the share of the asthmatic population that is under 18 years. This suggests that while children are more likely to have asthma than adults, the costs for children with asthma are comparable on a per-person basis.

From 1984-1986 to 1995-1996, the national prevalence of asthma, based on NHIS data, rose about 70%, compared to an increase in the general population of about 12%. This represents a dramatic increase in asthma prevalence. While the costs of asthma increased for most outcome categories, the percentage increases were somewhat lower than those for asthma prevalence. This reflects a negligible change in asthma-related hospitalizations, and a less than 50% increase in emergency room visits, outpatient physician visits, and mortality. However, prescription medication costs for asthma approximately doubled in real terms over the same period.

Combined, these results suggest that there has been some shift in costs from hospitalizations to prescription medication. This is consistent with the increased use of prescription medications in the day-to-day treatment of underlying asthma symptoms and prevention of exacerbations. How

6. After this paper was nearly completed, the National Heart, Lung, and Blood Institute released a report giving cost-of-illness estimates for heart and respiratory diseases in the United States (NHLBI, 2000). They report an annual cost of asthma of $11.3 billion in 1998 dollars. Very little was said in the report about how this estimate was developed. The references were largely personal communications and indicated that data from the mid-1990s were primarily used. This estimate is comparable to those obtained here.

much this may have contributed to the decline in per-asthmatic hospitalization is uncertain because decreased use of hospitalization for the provision of treatment is a common objective of the managed care system for providing services, which continues to increase its influence within the health care industry. Attributing this benefit fully to increased use of prescription medications is also complicated by noting that more effective emergency room treatment may also have reduced the number of hospitalizations. Also, emergency room visits and deaths due to asthma did not decline nearly as much as hospitalizations, on a per-asthmatic basis, suggesting an additional factor besides increased use of preventative medications in the decline in hospitalization. Improved medications would be expected to realize benefits across all three type of adverse outcomes.

Relative to other illnesses, asthma health care expenditures pose a greater out-of-pocket burden to patients and their families. About 25% of all asthma-related health care expenditures are paid by patients and their families. The figure for all health care expenditures is 10%. One of the differences is that only about 20% of asthma-related expenditures are paid by Medicare and other federal programs compared to 30% for all health care expenditures.

In terms of the future magnitude and composition of the national costs of asthma, much will depend on the success of implementing recommended treatment regimens such as those for prescription medications in the EPR-2 (U.S. Department of Health and Human Services, 1997). These regimens generally focus on achieving a state where asthma patients can control their symptoms largely through the recognition and avoidance of triggers and the use of self-administered medications. If successful, these treatment regimens would be expected to reduce the per-asthmatic expenditures on hospital and emergency room services, all else being equal, as severe exacerbations that currently require care in these locations become less frequent.

The second unknown with regard to the future magnitude of the national cost of asthma estimates is the future direction of asthma prevalence. Currently, the magnitude of the increase in asthma prevalence would be expected to ensure increases in the national costs of asthma, regardless of what benefits new treatment guidelines could offer. However, these increases could hide a story of improved asthma management if the average annual costs per asthmatic decreased at the same time. In either case, while reducing asthma prevalence by controlling the development of new cases holds the greatest promise for eventually controlling the national costs of asthma, this is an area where definitive medical knowledge and available medical options are currently quite limited.

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