A comprehensive study of the direct and indirect costs of adult asthma

Miriam G. Cisternas, MA,[a] Paul D. Blanc, MD, MSPH,[b,c] Irene H. Yen, PhD, MPH,[b] Patricia P. Katz, PhD,[b,d] Gillian Earnest, MS,[b] Mark D. Eisner, MD, MPH,[b] Stephen Shiboski, PhD,[e] and Edward H. Yelin, PhD[b,d] *Carlsbad and San Francisco, Calif*

Background: Asthma is a common and costly health condition, but most estimates of its economic effect have relied on secondary sources with limited condition-specific detail.
Objective: We sought to estimate the magnitude of direct and indirect costs of adult asthma from the perspective of society.
Methods: We used cross-sectional survey data from an ongoing community-based panel study of 401 adults with asthma originally derived from random samples of northern California pulmonologists, allergist-immunologists, and family practitioners to assess health care use for asthma, to assess purchase of items to assist with asthma care, and to measure work and other productivity losses. Unit costs derived from public-use and proprietary data sources were then assigned to the survey items.
Results: Total per-person annual costs of asthma averaged $4912, with direct and indirect costs accounting for $3180 (65%) and $1732 (35%), respectively. The largest components within direct costs were pharmaceuticals ($1605 [50%]), hospital admissions ($463 [15%]), and non–emergency department ambulatory visits ($342 [11%]). Within indirect costs, total cessation of work accounted for $1062 (61%), and the loss of entire work days among those remaining employed accounted for another $486 (28%). Total per-person costs were $2646, $4530, and $12,813 for persons self-reporting mild, moderate, and severe asthma, respectively ($P < .0001$, 1-way ANOVA).
Conclusion: Asthma-related costs are substantial and are driven largely by pharmaceuticals and work loss. (J Allergy Clin Immunol 2003;111:1212-8.)

Key words: *Asthma, direct costs, indirect costs, health care use, work losses*

Abbreviations used
AWP: Average wholesale price
HSD: Honestly Significantly Different [test]
HMO: Health maintenance organization
MEPS: Medical Expenditure Panel Survey

The present study is a comprehensive assessment of the annual cost of asthma. There is a growing body of literature on the cost of all forms of respiratory disease in general and asthma in particular in the United States[1-15] and internationally.[16-27]

The studies of the economic effect of asthma have been principally of 2 kinds: those using population-based sampling frames or administrative databases to provide cost estimates for entire regions or nations[2-5,7] and those using clinical-based sampling frames.[6,8,13,19,25] The population-based studies have greater generalizability, whereas the clinical-based studies have greater diagnostic certainty and, frequently, data on disease severity that is particularly relevant to asthma costs.

The present study derives from northern California adults with asthma obtaining care from random samples of pulmonologists, allergist-immunologists, and family practitioners over a prospective period of enrollment. Thus, although this is a clinical cohort, it is based on systematic samples of community and not tertiary-care practitioners. We estimated the costs of asthma from the perspective of society: the approximate value to society of the resources put into medical care for those with the illness and of the lost productivity in work and nonwork activities alike, regardless of who actually pays for such costs.[28]

In addition to the comprehensiveness of the sampling frame, the present study differs from prior studies using clinical sampling because of the scope of the direct costs enumerated, including nontraditional medical therapies and nonmedical expenses. The study also is able to provide estimates of a wide array of indirect costs because of the detailed occupational histories in the survey interviews conducted with the persons with asthma. Finally, because we developed alternative estimates of the costs of hospital admissions and medications and have validated the self-report of pharmaceutical use in a subsample of the study respondents, we were able to gauge the extent to which estimates of the total costs of asthma are sensitive to the choice of a cost measure or inaccuracy of reporting.

METHODS

Subject interviews

The data collection protocol was approved by the University of California, San Francisco, Committee on Human Research. The University of California, San Francisco Asthma Panel sampled persons with asthma recorded on visit logs maintained by a random sample of northern California adult pulmonologists, allergist-immunologists,

From [a]MGC Data Services, Carlsbad; and [b]the Department of Medicine, [c]the Cardiovascular Research Institute, [d]the Institute for Health Policy Studies, and [e]the Department of Biostatistics and Epidemiology, University of California, San Francisco.
Supported by grants R01 ES10906, R01 HL56538, and R01 OH03480.
Received for publication October 22, 2002; revised February 1, 2003; accepted for publication February 5, 2003.
Reprint requests: Edward H. Yelin, PhD, Box 0920, University of California, San Francisco, San Francisco, CA 94143-0920.

0091-6749/2003 $30.00 + 0
doi:10.1067/mai.2003.1449

and family practice physicians.[29,30] At the time of original enrollment, subjects ranged in age from 18 to 50 years and were interviewed at 18- to 24-month intervals thereafter. The 401 follow-up interviews on which this article is based occurred between 1998 and 1999.

The interviews, conducted by a trained survey worker, included questions on health care use in the year before the survey, including medications, expenditures other than for direct medical care that are made to reduce the effect of asthma (eg, transportation for asthma-related medical care), hired assistance for household tasks and repairs, outlays for asthma control measures (eg, air filters), and losses in productivity. For the latter, participants provided information as to their employment status and occupation at the time of diagnosis if they were 18 years of age or older at the time (or occupation details of their first job if they were given a diagnosis as children); they also provided information on changes in employment status, occupation, and work hours at every follow-up interview. Indirect costs associated with lost productivity around the house were also ascertained.

Cost perspective

All costs tabulated for this study are specifically associated with asthma, either because the specific survey item assessed is consistent with asthma-specific treatment (eg, asthma bronchodilators) or because the respondent was asked to specifically attribute use to asthma (eg, the number of emergency department visits for asthma ascertained in the interview and not simply the total number of emergency department visits experienced for any reason). All costs are reported from the perspective of society.[28] Thus the costs enumerated below differ from costs, charges, or expenditures experienced solely by a payer, the health care provider, or the individual with asthma.

Assigning unit prices to direct medical care use

Hospitalization, emergency department, and ambulatory visits. We used the 1996 and 1997 Medical Expenditure Panel Survey (MEPS) data from persons aged 18 to 55 years as the primary source of unit costs for hospitalizations, emergency department visits, ambulatory visits (by kind of provider), and allergy desensitization injections associated with a primary International Classification of Diseases–9th revision–Clinical Modification diagnostic code of 493.[31-33] All the average costs from MEPS were inflated to 1998 equivalents by using changes in the medical component of the Consumer Price Index between 1996 or 1997 and 1998.[34]

Alternative (sensitivity) values for hospitalization costs were based on 2 other sources. Charges associated with calendar year 1998 discharges from a single northern California tertiary academic medical center were extracted by using the same criteria as for MEPS above and then analyzed to yield a fixed cost plus a daily cost to which were added professional fees.[35] A second source of sensitivity data was derived from 1995 to 1998 discharges extracted from a northern California closed-panel health maintenance organization (HMO).

Medications. The source of unit costs for all prescribed and over-the-counter medications is the *1999 Red Book*,[36] which provides average wholesale prices (AWPs). No dispensing fee was added to any unit costs for medications to avoid double counting. Prescription and over-the-counter drug costs for each subject were calculated on the basis of the duration of use over the year before interview. For medicines that fluctuate in frequency depending on symptoms and possible illness flares (eg, inhaled bronchodilators), we surveyed subjects specifically as to dosing and used the subject's reported frequency to calculate average daily medication use. For other medications, we assigned the standard recommended dose.[37-42]

Herbal and alternative remedies attributed to asthma (ephedra products, teas to "ease breathing," Chinese medicinal products, vitamins, and homeopathic remedies) for which costs could not be ascertained in a systematic fashion were assigned a value of $10 per month.

Two sensitivity analyses concerning the costs of medications were performed. First, we substituted 75% of the AWP for 100% of the AWP. We also conducted a validation analysis on the basis of computerized prescription data for 54 of 110 subjects who were members of a single HMO. The 56 remaining subjects not included in this analysis did not provide written consent for the medical record release. We examined the most common asthma-related medications, assessing agreement as to whether they were used in the past 18 months through calculation and interpretation of the κ statistic.[43] Of the 7 medications we analyzed, one displayed excellent agreement ($\kappa = 0.90$), 5 displayed fair to good agreement ($\kappa = 0.51$-0.74), and only one (β-agonists) suggested poor agreement ($\kappa = 0.39$). These results, along with errors and omissions included in administrative data and the likelihood that many of these subjects might have had dual coverage, indicate that the patient response data are, in general, quite reliable.

Outpatient medical procedures. The medical procedures included in this study were flu and pneumonia vaccinations, spirometry, allergy shots, and allergy testing. For flu and pneumonia vaccinations, we consulted the *1999 Red Book* to obtain wholesale prices for the flu and pneumonia vaccine antigens.[36] For spirometry, we used the price listed in the National Allowable Average from the *Physicians Fee and Coding Guide* for CPT codes 94010 and 94010-26.[35] To assess the cost of allergy shots, we used data from the 1996-1997 MEPS Office-Based Provider Visits file, subsetted for people ages 18 to 55 years with the first reason for the visit of asthma (International Classification of Diseases–9th revision–Clinical Modification = 493). The mean expense, inflated to 1998 dollars, from office visits with nurses or nurse practitioners (but no other types of providers), including allergy shots, was used in our calculations. For allergy skin testing of a standard aeroallergen panel, we used the fee schedule of an academic medical center outpatient allergy practice.

Assignment of direct nonmedical costs

We included 4 direct nonmedical costs in this study. Respondents were asked to estimate transportation costs for asthma-related medical care (eg, traveling to physicians' offices) and payments for purchase of asthma-control products (eg, allergy-free pillows), routine household chores, and major home repairs that were stated to be asthma related.

Assignment of indirect costs

Wage losses associated with work disability. We calculated lost wages for 3 different effects of asthma on employment: persons who were not working at all because of their asthma, persons who reduced their hours because of their asthma, and persons who missed days or shifts because of their asthma.

We used information about the respondents' current or past occupation and employment status to assign costs to employment losses associated with asthma, assigning the matching 1990 census occupation codes to those jobs.[44] Indirect costs as a result of lost wages were based on the mean hourly wage for a given census occupation code from the National Compensation Survey, 1998.[45] For 2 subjects without job-specific occupational information, we used the mean hourly earnings figure for the nation in 1998. For respondents whose asthma caused them to stop working completely, lost wages were calculated as the equivalent of 1 year's full-time or part-time wages, depending on their level of employment before cessation. On the basis of the subjects' responses to reduced work hours or lost days caused by asthma, we calculated the amount of lost wages caused by asthma.

TABLE I. General sociodemographic characteristics of interviewed adults with asthma, 1998-1999 (n = 401)

Characteristics	Frequency N	Frequency %
Female sex	285	71
Race/ethnicity		
Hispanic	43	11
Non-Hispanic white	289	72
Black	27	7
Asian/pacific Islander	26	6
Native American	15	4
Unknown	1	0
Education		
Less than high school	11	3
High school graduate	75	19
Some college	147	37
College graduate	80	20
Postgraduate	88	22
Marital status		
Single (never married)	55	14
Married/long-term relationship	267	67
Widowed/separated/divorced	56	14
Unknown	23	6
Family income		
≤$20,000	32	8
$20,001-$40,000	59	15
$40,001-$50,000	46	11
$50,001-$75,000	91	23
>$75,000	124	31
Declined to state	49	12
Self-rated asthma severity		
Mild	200	50
Moderate	137	34
Severe	64	16

The mean age at interview was 44 ± 8 years.

Other productivity losses attributed to asthma disability. We also accounted for reduced productivity of persons who did not work outside the home but reported an average weekly number of hours unable to perform their routine household chores. Therefore this was only assigned a cost if the subject did not already report any direct costs for housekeeping help to avoid double counting (see above). The method used to calculate this lost productivity in dollar terms was to multiply these weekly hours by 52. Their time was valued by using the 1998 National Compensation Survey mean hourly wage for maids and housemen.[45]

Analyses

All analyses were performed with version 8.1 of the SAS System (SAS Industries, Cary, NC). We calculated the descriptive frequencies for direct medical, direct nonmedical, and indirect asthma costs overall and stratified by asthma severity. Asthma severity was based on subject self-classification as having mild, moderate, or severe disease by using the survey item originally developed by Janson-Bjerklie et al.[46] As a sensitivity analysis, we estimated costs as a function of a modified version of a previously validated severity score that was calculated on the basis of a history of hospital admission and intubation, current asthma symptoms, systemic (noninhaled) corticosteroid use, and corticosteroid dependency.[30,47]

We calculated relative SEs (the SE divided by the mean value) for all means to ascertain the stability of the estimate. Any estimate with a relative SE of greater than 0.3 is flagged as unstable. We used 1-way ANOVA as the method for testing bivariate relationships between costs and severity of asthma after first transforming the costs in question to their natural log. This log transformation is an established procedure used by health economists to compensate for the skewed nature of cost data. The Tukey Honestly Significantly Different (HSD) test was used as the multiple comparison procedure to ascertain which of the 3 severity groups were significantly different from one another in terms of cost of asthma.

RESULTS

Demographics and self-rated disease severity

Table I shows the demographic and clinical characteristics of the 401 subjects interviewed in 1998 and 1999.

Direct costs

Direct costs for both medical care use and nonmedical asthma-related items are shown in Table II. Virtually all of the panel subjects reported taking at least one asthma-related medication (98%); three quarters of the subjects reported ambulatory asthma visits other than to emergency departments, and the same percentage reported at least one outpatient procedure for asthma in the previous year. Relatively small proportions reported emergency department visits or hospital admissions. Sixty percent of the respondents reported direct nonmedical costs; about half made direct expenditures for household allergy control measures, and approximately one fifth paid for transportation associated with medical care.

Medical costs accounted for 85% of the direct costs, with prescription medications, at $1605, accounting for half of the total direct costs. In the sensitivity analysis, when we used 75% of the AWP as the unit price for drugs, medications, at $1271, accounted for 45% of total direct costs. Other large components of direct costs included hospital admissions (15% of the total) and ambulatory care, excluding the use of emergency departments (11%). Emergency department use (6%) and outpatient procedures (3%) accounted for relatively little of the total cost. Of the $342 per person associated with non–emergency department ambulatory care, visits to physicians were responsible for all but $32. Of the $1605 total per person accounted for by medications, prescription asthma bronchodilators and anti-inflammatory drugs were responsible for $962, whereas other asthma prescriptions and nonprescription drugs (including herbal remedies) accounted for $581 and $61, respectively.

We varied the base unit price of hospital admissions by substituting estimates from an academic teaching hospital and an HMO system, respectively. The increase in mean total direct costs was relatively small: $259 (8%) by using the HMO estimate and $386 (12%) by using the academic facility–based price.

The costs of transportation to asthma medical care appointments, affecting 21% of the respondents, averaged $17 (such costs amounted to less than $60 among those reporting severe disease). The costs associated with

TABLE II. Direct annual asthma-related costs by category of interviewed adults with asthma (n = 401) adjusted to 1998 dollars

		Annual cost (US$) for all subjects		
Source of cost	**% With any cost**	**Mean**	**SD**	**% Total***
Medical treatment of asthma	99	2697	4182	85
Emergency department visits	15	184†	1182	6
Hospitalizations	7	463†	3137	15
Medications	98	1605	868	50
Prescription bronchodilators and anti-inflammatory agents	94	962	676	30
Other asthma-related prescription medications‡	87	581	391	18
Over-the-counter and herbal remedies for asthma	62	61	93	2
Ambulatory visits	75	342	532	11
Physicians and osteopaths	74	310	499	10
Nurse practitioners	1	1†	9	0
Other practitioners§	4	31	169	1
Outpatient medical procedures‖	75	104	246	3
Nonmedical asthma costs	60	483	1180	15
Transportation for medical care	21	17	70	1
Housekeeping assistance caused by disability	13	186	620	6
Help with special household chores	8	119	584	4
Household allergy control measures	51	161	465	5
Total costs	99	3180	4439	100

*This column refers to the percentage of total direct costs for each source of cost.
†Estimate has low statistical reliability (relative SE >30%).
‡Includes nasal steroid sprays, ipratropium bromide (Atrovent) nasal spray, nasal antihistamine spray, antihistamine tablets, antibiotics, antiulcerants, antifungals, over-the-counter nasal sprays.
§Includes the following practitioners: acupuncturist, acupressurist, counselor-psychologist, chiropractor, homeopathy practitioner, spiritual healer, and massage therapist.
‖Includes influenza and pneumonia vaccinations, spirometry, allergy shots, and allergy testing.

TABLE III. Indirect annual asthma-related costs of interviewed adults with asthma (n = 401) adjusted to 1998 dollars

		Annual cost (US$) for all subjects		
Source of cost	**% With any cost**	**Mean**	**SD**	**% Total***
Lost work productivity	18	1719	5535	99
Stopped working altogether because of asthma	5	1062	5078	61
Decrease hours because of asthma	1	66†	1222	4
Lost full work days because of asthma	11	486	1832	28
Lost part work days because of asthma	6	105	515	6
Lost other productivity‡	1	13†	176	1
Total	19	1731	5533	100

*This column refers to the percentage of total indirect costs for each source of cost.
†Estimate has low statistical reliability (relative SE >30% of mean).
‡Household chores for homemakers who did not report any direct expenditures for household help.

housekeeping assistance, affecting 13% of respondents, averaged $186; the costs associated with getting help with special home-improvement tasks, affecting 8%, averaged $119, and the costs associated with household allergy control measures, affecting about half of the subjects, averaged $161 per person. Thus the total of these nonmedical expenses yielded a mean of $483 per person per year, representing 15% of the total direct costs for these individuals.

Indirect costs

Indirect costs associated with asthma averaged $1731 per person, even though fewer than one fifth experienced any such costs (Table III). Sixty-one percent ($1062) of the indirect costs were due to the total cessation of work activities attributed to asthma, although only 5% of the respondents had stopped working altogether for this reason. Another 28% and 6% of the indirect costs, respectively, were due to the loss of full and partial work days among those who remained employed. Relatively small proportions of all indirect costs were associated with a decrease in hours of work (4%) and productivity losses in household chores beyond the direct purchase of such services (1%). We did not include in these cost estimates the effect of asthma mortality, although 2 asthma-related deaths had occurred within the cohort during the 18-month period preceding the scheduled follow-up survey interview on which this analysis was based.

TABLE IV. Direct medical, direct nonmedical, indirect, and total asthma-related annual costs of adults with asthma stratified by self-assessed severity adjusted to 1998 dollars

	Direct medical costs*							
Self-assessed severity	Medications	Ambulatory care	Hospitalizations	Other medical†	Subtotal	Direct non-medical costs*	Indirect costs*	Total costs
Mild (n = 200)	$1252 (47)	$198 (7)	$102 (4)	$129 (5)	$1681 (64)	$382 (14)	$582‡ (22)	$2646
Moderate (n = 137)	$1746 (39)	$324 (7)	$215‡ (5)	$188 (4)	$2473 (55)	$570 (13)	$1488 (33)	$4530
Severe (n = 64)	$2404 (19)	$833 (7)	$2122‡ (17)	$995‡ (8)	$6354 (50)	$613 (5)	$5846 (46)	$12,813
Total (n = 401)	$1605 (33)	$342 (7)	$463‡ (9)	$287 (6)	$2697 (55)	$483 (10)	$1732 (35)	$4912

*Cells represent mean cost (percentage) of total mean costs per person.
†Residual category includes emergency department and outpatient medical procedures.
‡Estimate has low statistical reliability (relative SE >30% of mean).

Effect of severity on costs

Table IV displays the various categories of costs as a function of self-reported asthma severity. Mean direct medical costs, driven in large part by medication and ambulatory care, increased from $1681 for the half reporting mild asthma to $2473 among the third reporting moderate disease and to $6354 for the 16% with severe disease. Direct nonmedical costs increased from $382 to $570 to $613 for the groups with mild, moderate, and severe disease, respectively. The overall differences in logged direct costs by severity level were statistically significant, (F[2,398]; $P < .0001$), as were the differences in costs among the 3 groups in pairwise comparisons ($P < .05$, Tukey HSD test). Although direct medical care costs were over 3 times as great among those with severe as among those with mild self-reported asthma ($6354 vs $1681), indirect costs increased 10-fold ($5846 vs $582). Total costs averaged $4912 among all persons with asthma in the study; among those with mild, moderate, and severe self-reported asthma, total costs were $2646, $4530, and $12,813, respectively. Once again, a 1-way ANOVA of the logged costs (F[2,398]; $P < .0001$) and Tukey HSD test indicate that these differences were significantly different, both overall and between severity levels. In the sensitivity analysis on the basis of the modified severity score of Eisner et al,[30,47] total costs were $2234, $5550, and $14,541 among those with mild, moderate, and severe disease, respectively.

Table IV also shows how the distribution of costs by category of expenses differed on the basis of self-reported severity of asthma. For persons with mild or moderate disease severity, medications comprised 47% and 39% of total costs, but for those with severe asthma, medications comprised only 19% of total costs (although the absolute magnitude of medication costs was greater). For persons with self-reported mild or moderate asthma, hospital admissions were absolutely ($102 and $215, respectively) and relatively (4% and 5%, respectively) small, whereas among persons with severe self-reported asthma, hospital admissions averaged $2112 or 17% of total costs. The latter group also had relatively high medical care costs of $995 (8% of the total) within the "other" direct medical category, incorporating visits to an emergency department and outpatient procedures. Persons with mild and moderate asthma experienced "other" direct medical costs of only $129 (5%) and $188 (4%), respectively. On the other hand, ambulatory care represented 7% of total direct medical care costs in all 3 severity groups. Overall, direct medical care costs accounted for 55% of the total costs of $4912, direct nonmedical costs accounted for 10%, and indirect costs accounted for 35%. Indirect costs were a larger share of the total among persons with severe self-reported asthma (46%) than among those with mild or moderate disease (22% and 33%, respectively).

DISCUSSION

The present study of the costs of asthma, like many before it, is based on a clinical sample. Unlike those before it, however, it derives from the survey responses of persons with asthma from random samples of a wide range of physicians, and it includes a more varied array of direct and indirect costs and incorporates alternative values for the unit price for hospital admissions. We found that direct medical costs averaged $2697 per person (using the base case unit price for hospital admissions) and were not highly sensitive to the unit price applied (total direct costs varied by no more than about 12% from the base case estimate using the alternate unit prices).

Medications accounted for the largest share of direct costs (50%), principally because of the high unit cost and widespread use of prescription bronchodilators and anti-inflammatory drugs and were not sensitive to the alternate pricing strategy. After medications, hospital admissions were the next largest component, about 15% of the direct cost total. Medication costs were incurred by 98% of respondents. In contrast, the 15% of the direct cost total associated with hospital admissions were incurred by only a small proportion of the persons with asthma (approximately 7%). Thus the high medication costs we observed are due to the combination of frequent use and high unit prices, whereas the high cost of hospital admissions is principally the result of high unit prices. Ambulatory care represented a relatively small portion of the total direct costs (11%), even though three quarters of the persons with asthma incurred some such costs during the year. The generalizability of the study might be limited because California has a higher concentration of managed

care settings than most other states, which, in turn, exerts a downward pressure on costs of care.[48] However, the estimate of total direct medical costs from this study ($2697) is very similar to the estimate of the total direct medical costs for persons with asthma of $2973 the authors made using the 1996 MEPS, although the latter estimate includes some costs not directly attributable to asthma.[3] The estimate would appear to be higher than that of the range of from $326 to $1315 reported by Weiss et al[2] in reviewing the cost of asthma literature (the range, updated to 1998 terms, would be $346 to $1395) or than the estimate of $1096 reported by Smith et al[5] for 1994, which, when updated to 1998 terms, would be $1163. The similarity between the results of the population-based MEPS and the present clinical-based study indicate that the estimate from this study is not prone to a substantial selection bias, although some bias might remain. Instead, the increase relative to earlier studies is probably the result of the fuller accounting of the kinds of costs and growth in the magnitude of costs within individual categories, particularly medications.

However large direct costs of asthma are, indirect costs, principally associated with reduction of work activities, also represent a sizable burden.[49] Almost two thirds of all indirect costs were due to the complete cessation of employment rather than to the reduction of hours or the loss of partial or total days among those who remained employed. Nonetheless, we did not estimate the economic effect of asthma on quality of life outside of work and housework activities. Such effects are common and highly valued by persons with asthma,[50] although difficult to price in economic terms.

We observed that both direct and indirect costs increase monotonically and dramatically with increases in self-reported severity of disease. Although these are cross-sectional data, the relationship between the magnitude of both direct and indirect costs and self-reported severity are consistent with the hypothesis that interventions that controlled the level or progression of the asthma would ultimately reduce the sizable costs associated with this illness. Approximately 3.5 million American adults aged 35 to 64 years have symptomatic asthma.[51] If the results of the present study concerning the distribution of self-reported severity levels among adults and their costs were applied to such national prevalence data, the savings that might accrue from a 5% shift in the proportion from severe to moderate asthma would be in the range of $1.4 billion dollars annually.

Given that the results of the present study indicate that the costs of asthma are $4912 per person per year, society would appear to have ample incentive to test interventions to reduce these costs.

We acknowledge the mentorship of Dr Curtis Henke, deceased.

REFERENCES

1. Weiss K, Sullivan K, Lyttle C. Trends in the cost of illness for asthma in the United States, 1985-1994. J Allergy Clin Immunol 2000;107:494-9.
2. Weiss K, Sullivan S. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol 2001;107:3-8.
3. Yelin E, Trupin L, Cisternas M, Eisner M, Katz P, Blanc P. A national study of medical care expenditures for respiratory conditions. Eur Respir J 2002;19:414-21.
4. Weiss K, Gergen P, Hodgson T. An economic evaluation of asthma in the United States. N Engl J Med 1992;326:862-6.
5. Smith D, Malone D, Lawson K, Okamoto L, Battista C, Saunders W. A national estimate of the economic costs of asthma. Am J Respir Crit Care Med 1997;156:787-93.
6. Lozano P, Fishman P, VonKorff M, Hecht J. Health care utilization and cost among children with asthma who were enrolled in a health maintenance organization. Pediatrics 1997;99:757-64.
7. Lozano P, Sullivan S, Smith D, Weiss K. The economic burden of asthma in US children: estimates from the National Medical Expenditure Survey. J Allergy Clin Immunol 1999;104:957-63.
8. Stanford R, McLaughlin T, Okamoto L. The cost of asthma in the emergency department and hospital. Am J Respir Crit Care Med 1999;160:211-5.
9. Stoupe K, Gaskins D, Murray M. Health care costs of inner-city patients with asthma. J Asthma 1999;36:645-55.
10. Malone D, Lawson K, Smith D. Asthma: an analysis of high-cost patients. Pharm Pract Manag Q 2000;20:12-20.
11. Birnbaum H, Berger W, Greenberg P, Holland M, Auerback R, Atkins K, et al. Direct and indirect costs of asthma to an employer. J Allergy Clin Immunol 2002;109:264-70.
12. Leigh J, Romano P, Schenker M, Kreiss K. Costs of occupational COPD and asthma. Chest 2002;121:264-72.
13. Ungar W, Coyte P. Prospective study of the patient-level cost of asthma care in children. Pediatr Pulmonol 2001;32:101-8.
14. Piecoro L, Potoski M, Talbert J, Doherty D. Asthma prevalence, cost, and adherance with expert guidelines on the utilization of health care services and costs in a state Medicaid population. Health Serv Res 2001;36:357-71.
15. Grupp-Phelan J, Lozano P, Fishman P. Health care utilization and cost in children with asthma and selected comorbidities. J Asthma 2001;38:363-73.
16. Weisflog D, Matthys H, Virchos J. Epidemiology and costs of bronchial asthma and chronic bronchitis in Germany. Dtsch Med Wochenschr 2001;126:803-9.
17. Szucs T, Anderhub J, Rutishauser M. Determinants of health care costs and patterns of care of asthmatic patients in Switzerland. Schweiz Med Wochenschr 2000;130:305-13.
18. Feenstra T, van Genugeten M, Postma M, Rutten-Van Molken M. Prevalence and costs of asthma and COPD in the Netherlands [abstract]. Ann Meet Int Soc Tech Assess Health Care 1999;15:57.
19. Godard P, Chanez P, Siraudin L, Nicoloyannis N, Duru G. Costs of asthma are correlated with severity: a 1-yr prospective study. Eur Respir J 2002;19:61-7.
20. Krahn M, Berka C, Langlois P, Detsky A. Direct and indirect costs of asthma in Canada, 1990. CMAJ 1996;154:821-42.
21. Mellis C, Peat J, Bauman A, Woolcock A. The cost of asthma in New South Wales. Med J Aust 1991;155:522-8.
22. Cavazos G, Contreras Castillo J, Martinez Llano E, Soni Duque D. Economic study on asthma in Mexico. Rev Alerg Mex 2000;47:96-9.
23. Kiivet R, Kaur I, Lang A, Aaviksoo A, Nirk L. Costs of asthma treatment in Estonia. Eur J Public Health 2001;11:89-92.
24. Chew F, Goh D, Lee B. The economic cost of asthma in Singapore. Aust N Z J Med 1999;29:228-33.
25. Awadh Behbehani N, Grunfeld A, FitzGerald J. Health care costs associated with acute asthma: a prospective economic analysis. Can Respir J 1999;6:521-5.
26. Hoskins G, McCowan C, Thomas G, Smith B, Silverman S. Risk factors associated with asthma attack. Thorax 2002;55:19-24.
27. Serra-Batlles J, Plaza V, Morejon E, Comella A, Brugues J. Cost of asthma according to the degree of severity. Eur Respir J 1998;12:1322-6.
28. Drummond M, O'Brien B, Stoddart G, Torrance G. Methods for the evaluation of health care programs. 2nd ed. New York: Oxford University Press; 1997.
29. Blanc P, Cisternas M, Smith S, Yelin E. Asthma, employment status, and disability among adults treated by pulmonary and allergy specialists [published erratum appears in Chest 2000;118:564]. Chest 1996;109:688-96.
30. Eisner MD, Katz PP, Yelin EH, Henke J, Smith S, Blanc PD. Assessment of asthma severity in adults with asthma treated by family practitioners, allergists, and pulmonologists [published erratum appears in Med Care 2000;38:880-5]. Med Care 1998;36:1567-77.
31. Cohen S. Sample design of the 1996 Medical Expenditure Panel Survey

Household Component. MEPS Methodology Report No. 2. Rockville, Md: Agency for Health Care Policy and Research; 1997. AHCPR publication no. 97-0027.
32. Agency for Health Care Quality and Research. MEPS household component 1996 full year use and expenditure data: public use documentation. Rockville, Md: Agency for Health Care Policy and Research; 1999. Publication no. C6-C11.
33. Cohen SB. Sample design of the 1997 Medical Expenditure Panel Survey Household Component. MEPS Methodology Report no. 11. Rockville, Md: Rockville, Md: Agency for Health Care Policy and Research; 2000. AHRQ publication no. 01-0001.
34. US Bureau of the Census. Statistical abstract of the United States, 2001. Washington, DC: USGPO; 2002.
35. Healthcare Consultants of America. Physicians fee and coding guide. Augusta, Ga: Healthcare Consultants of America; 2001.
36. Medical Economics Company. 1999 red book. Montvale, NJ: Medical Economics Company; 1999.
37. The Medical Letter, Inc. Acrivastine/pseudoephedrine (Semprex-D) for seasonal allergic rhinitis. Med Lett Drugs Ther 1994;36:78-80.
38. The Medical Letter, Inc. Cetirizine—a new antihistamine. Med Lett Drugs Ther 1996;38:21-3.
39. The Medical Letter, Inc. Systemic antifungal drugs. Med Lett Drugs Ther 1997;39:86-8.
40. The Medical Letter, Inc. Cefdinir—a new oral cephalosporin. Med Lett Drugs Ther 1998;40:85-7.
41. The Medical Letter, Inc. Mometasone furoate nasal spray for allergic rhinitis. Med Lett Drugs Ther 1999;41:16-7.
42. The Medical Letter, Inc. Drugs for asthma. Med Lett Drugs Ther 2000;42:19-23.
43. Fleiss JL. Statistical methods for rates and proportions. 2nd ed. New York: John Wiley and Sons, Inc; 1981.
44. Bureau of the Census. 1990 census of population and housing alphabetical index of industries and occupations. Washington, DC: US Department of Commerce; 1992.
45. US Department of Labor, Bureau of Labor Statistics. National compensation survey: occupational wages in the United States, 1998. Washington, DC: US Department of Labor; 1999.
46. Janson-Bjerklie S, Ferketich S, Benner P, Becker G. Clinical markers of asthma severity and risk: importance of subjective as well as objective factors. Heart Lung 1992;21:265-72.
47. Eisner M, Katz P, Yelin E, Shiboski S, Blanc P. Risk factors for hospitalization among adults with asthma: the influence of sociodemographic factors and asthma severity. Respir Res 2001;2:53-60.
48. Dranove D, Carol S, William W. Determinants of managed care penetration. J Health Economics 1998;17:729-45.
49. Blanc P. Characterizing the occupational impact of asthma. In: Weiss K, Buist A, Sullivan S, eds. Asthma's impact on society: the social and economic burden. Lung Biology in Health and Disease. New York: Marcel Dekker; 1999. p. 55-75.
50. Katz P, Yelin E, Eisner M, Earnest G, San Pedro M, San Pedro M, et al. Role of physical function in asthma-specific quality of life:general function vs. performance of valued life activities [abstract]. Am J Respir Crit Care Med 2002;165:A122.
51. Surveillance of asthma—United States, 1980-1999. MMWR Morb Mortal Wkly Rep 2002;51(SS1):1-13.