

# Costs of Asthma Among US Working Adults

Rahul Shenolikar, PhD; Xue Song, PhD; Julie A. Anderson, MPH; Bong Chul Chu, PhD;  
and C. Ron Cantrell, PhD

**A**sthma is a common chronic disorder of the airways that is characterized by variable and recurring symptoms, airflow obstruction, bronchial hyperresponsiveness, and underlying inflammation.<sup>1</sup> According to the National Center for Health Statistics,<sup>2</sup> in 2005 an estimated 7.7% of persons living in the United States (22.2 million) had asthma, 4.2% (12.2 million) had at least 1 asthma attack in the previous year, and 11.2% (32.6 million) had been diagnosed as having asthma during their lifetime.

The annual cost of asthma is estimated to be almost \$18 billion, of which \$10 billion is owing to direct costs and \$8 billion is owing to indirect costs.<sup>3</sup> In 2002, 11.8 million workdays and 14.7 million school days were missed because of asthma.<sup>2</sup> Previous studies have shown that asthma significantly increases direct and indirect costs. Cisternas et al<sup>4</sup> estimated costs using a cross-sectional survey of 401 adult patients in northern California and found that total annual costs for patients with asthma averaged \$4912, with 65% in direct costs and 35% in indirect costs. For indirect costs, total cessation of work accounted for 61% of costs, and loss of entire workdays among those who remained employed accounted for 28%. In another study that assessed costs of asthma to an employer between 1996 and 1998, Birnbaum et al<sup>5</sup> found that for employees with asthma having disability claims total medical costs were approximately 3 times higher than those for employees without asthma. Furthermore, among employees with asthma, wage replacement costs for workdays lost as a result of disability and sporadic absenteeism (40%) accounted for almost as much as medical costs (43%). Both of these studies lacked generalizability, as the study by Cisternas et al focused on a specific geographic region and the study by Birnbaum et al was based on a single employer assessing workers with asthma who had filed disability claims. In addition, Cisternas and colleagues used self-reported measures to estimate costs instead of claims, which can be a more reliable measure. Colice et al<sup>6</sup> studied patients with persistent asthma among 17 large self-insured companies in the United States using a claims database; the study period was 2001 to 2003, and indirect costs were drawn from only 9 companies. Their study found that patients with persistent asthma had \$4412 more in annual total medical costs and \$924 more in work

loss compared with patients without asthma. The objective of the present study was to evaluate the incremental direct and indirect costs incurred by

**Objectives:** To evaluate the effect of asthma on direct and indirect costs among US working adults.

**Study Design:** A case-control retrospective analysis was conducted. Data between January 1, 2003, and December 31, 2006, among patients aged 18 to 64 years with vs without asthma were extracted from MarketScan Research Databases. Patients with chronic obstructive pulmonary disease or emphysema were excluded, and all patients were required to have 12-month continuous enrollment before and after the index date. Outcomes included direct medical costs, the number of absence days, the number of short-term disability days, and associated indirect costs.

**Methods:** Patients with asthma were propensity score-matched to patients without asthma using nearest neighbor 1:1 with caliper. Subsequent multivariate analysis was conducted on matched samples to examine the marginal effect of asthma on direct and indirect costs.

**Results:** A total of 13,379 patients with asthma were propensity score-matched to 13,379 patients without asthma; in each cohort, 3453 patients had absence eligibility, and 8497 patients had short-term disability eligibility. Direct costs for patients with asthma were \$3762, and indirect costs were \$4572. Compared with the matched cohort without asthma, patients with asthma had \$1785 higher direct medical expenditures ( $P < .001$ ). Incremental indirect costs were \$191 for absenteeism ( $P = .007$ ) and \$172 for short-term disability ( $P < .001$ ).

**Conclusions:** Compared with patients without asthma, patients with asthma experience significantly higher direct medical costs and, although modest, significantly higher work loss. Treatments or interventions that prevent or reduce asthma symptoms may have a beneficial effect on medical costs and work absenteeism.

(*Am J Manag Care.* 2011;17(6):409-416)

## In this article

Take-Away Points / p410

[www.ajmc.com](http://www.ajmc.com)

Full text and PDF

For author information and disclosures,  
see end of text.

### Take-Away Points

Asthma has profound effects on medical costs and work productivity.

- Patients with asthma experienced significantly higher direct medical costs and modestly higher work loss than patients without asthma.
- Treatments or interventions that prevent or reduce asthma symptoms can potentially have a beneficial effect on medical costs and work absenteeism.

teristics using propensity score–matching techniques. This assured that the groups were composed of patients with similar factors likely to affect the outcomes; therefore, differences in costs between these 2 groups were attributable to the presence of asthma.

patients with asthma compared with patients without asthma using more recent data that are representative of typical US working adults.

## METHODS

### Data Sources

Two Thomson Reuters MarketScan Research Databases (<http://thomsonreuters.com/>), the Commercial Database and the Health and Productivity Management Database, were used in this study. These are large national databases constructed from paid medical and prescription drug claims of privately insured enrollees working for self-insured employers and their spouses and dependents. The data cover all US census regions and are representative of the US population with insurance provided by large employers. The Commercial Database contains inpatient, outpatient, and outpatient prescription drug experiences of 31.9 million enrollees and their dependents in 2006, covered under various fee-for-service and capitated health plans, including exclusive provider organizations, preferred provider organizations, point-of-service plans, indemnity plans, health maintenance organizations, and consumer-driven health plans. The Health and Productivity Management Database contains workplace absence, short-term disability, and workers' compensation data, which can be linked to medical and pharmacy data in the Commercial Database. The databases are unique because they allow examination of direct and indirect costs of patients by linking employees' medical and pharmacy claims to productivity data. Between 1997 and 2006, 41 employers covering more than 2.2 million employees have contributed to the Health and Productivity Management Database. Both the Commercial Database and the Health and Productivity Management Database were deidentified in compliance with regulations of the Health Insurance Portability and Accountability Act of 1996.

### Design

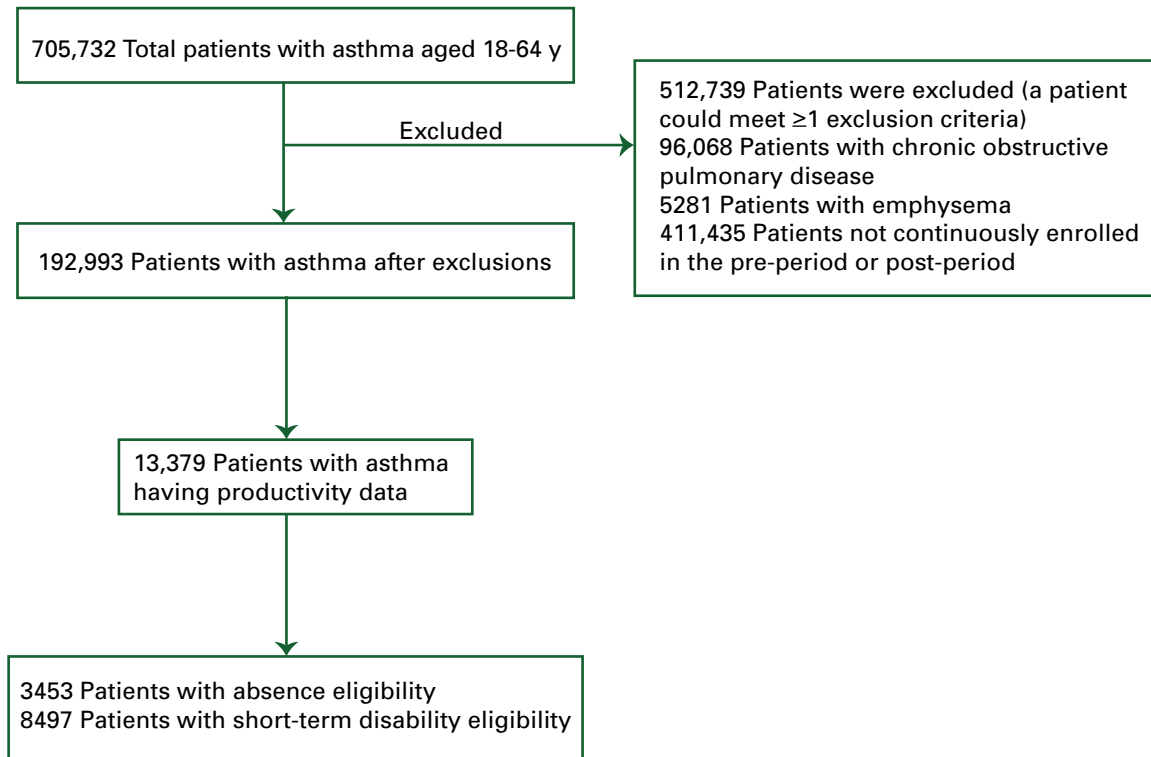
This study used a case-control design with retrospective claims analysis to compare direct and indirect costs between patients with asthma and their controls. To ensure that the difference between patients with vs without asthma represented the incremental direct and indirect costs, the groups were matched on patients' demographic and clinical charac-

### Patient Identification

All patients aged 18 to 64 years were identified as having asthma if they met 1 of the following criteria: (1) at least 1 inpatient stay or emergency department visit with asthma (*International Classification of Diseases, Ninth Revision, Clinical Modification* code 493.xx, excluding 493.2) listed as the principal diagnosis, (2) at least 2 outpatient visits on 2 unique dates with asthma listed in any diagnosis field, or (3) at least 1 outpatient visit with asthma listed in any diagnosis field and at least 1 asthma medication prescription between January 1, 2003, and December 31, 2005. Patients with any claim for chronic obstructive pulmonary disease (COPD) or emphysema at any time between January 1, 2002, and December 31, 2006, were excluded from the study because COPD and emphysema are also chronic lung diseases that affect patients' airways. Some of the medications used for asthma are also used for COPD and emphysema. Including patients with COPD or emphysema would have made it challenging to single out the effect of asthma on drug costs and total costs. The index date was the first asthma diagnosis or treatment claim date. All patients were required to be continuously enrolled with medical and pharmacy benefits for 12 months before (baseline period) and 12 months after (follow-up period) the index date.

The control group comprised patients aged 18 to 64 years without asthma diagnosis or treatment as already defined and without COPD or emphysema from January 1, 2002, to December 31, 2006. Patients in the control group also had 12-month continuous enrollment before and after the index date. The index date for patients without asthma was assigned based on the distribution of index dates among patients with asthma. The number of days between January 1, 2003, and the index date for patients with asthma was calculated for each patient with asthma, giving a range in the number of days (this range of days was referred to as the interval pool). The index date for patients without asthma was January 1, 2003, plus a random number drawn from the interval pool. After this assignment, patients with vs without asthma had similar distributions in the number of days between January 1, 2003, and the index date. Patients with vs without asthma were required to have productivity (Health and Productivity Management Database) data.

■ **Figure.** Flow chart of Patient Selection



The absence and short-term disability cohorts were not mutually exclusive; 537 patients had absence eligibility and at least short-term disability. Patients with workers' compensation but no absence eligibility or short-term disability eligibility (n = 1966) were excluded from the analysis of indirect costs.

**Outcome Measures**

The primary outcome measures in this study were direct medical costs and indirect costs associated with absence or short-term disability. Analysis of direct costs was performed for patients with complete medical and pharmacy claims. Direct costs were measured as total reimbursed amount, including patient copayment and deductibles. Total cost and its components (inpatient admissions, emergency department, outpatient, and pharmacy) were calculated from medical and pharmacy claims. All direct costs were inflated to 2006 US dollars using the medical service component of the Consumer Price Index from the Bureau of Labor Statistics (<http://www.bls.gov/cpi/>). Healthcare utilization was also summed for the 12-month follow-up period for all services.

Outcome measures for the analysis of indirect costs included the number of absence days from work, the number of short-term disability days, and associated indirect costs. Indirect costs were calculated for a subset of patients with full-time employment and absence or short-term disability eligibility during the 1-year follow-up period. Part-time workers were excluded from the analysis of indirect costs because absenteeism benefits offered to part-time workers

may differ from those offered to full-time workers, and this would affect the absenteeism pattern. In addition, part-time workers are usually not eligible for short-term disability, and calculation of short-term disability days and costs would not have been possible. For absence and short-term disability data fields, the start and end dates and the number of hours are reported in the Health and Productivity Management Database. The number of absence days and the number of short-term disability days were estimated as the number of hours absent or under short-term disability divided by 8 hours (equivalent to a typical working day). Indirect costs associated with absence were estimated as the number of absence days multiplied by age-, sex-, and region-specific wage rates from a 2006 population survey conducted by the US Census Bureau for the Bureau of Labor Statistics.<sup>7</sup> Because there is wide variation in short-term disability benefits depending on the size of a company and an employee's length of employment and no universal benefit rule, indirect costs associated with short-term disability were estimated using 75% of the wage rates in the base scenario. Sensitivity analysis was performed using 50% and 100% of the wage rates to examine the effect of short-term disability benefit on indirect costs.

■ **Table 1.** Demographic and Clinical Characteristics Among Patients With vs Without Asthma

Variable	Patients With Asthma (n = 13,379)	Patients Without Asthma (n = 13,379)	P Value <sup>a</sup>
<b>Age, mean (SD), y</b>	42.2 (9.5)	42.2 (9.6)	.44
<b>Female sex, %</b>	47.4	47.9	.41
<b>Geographic region, %</b>			
Northeast	24.4	24.4	.91
North Central	33.2	32.8	.36
South	31.6	31.8	.40
West	10.8	11.1	.58
<b>Plan type, %</b>			
Indemnity	6.6	7.0	.21
Health maintenance organization	15.0	15.1	.88
Point-of-service plan	27.9	27.4	.37
Preferred provider organization	49.5	49.4	.86
Other	1.0	1.1	.42
<b>Charlson Comorbidity Index, mean (SD)</b>	0.26 (0.65)	0.23 (0.73)	.001
<b>Comorbidities, %</b>			
Cancer	4.1	4.0	.73
Hypertension	13.6	14.4	.046
Heart disease	2.5	2.6	.79
Osteoarthritis	0.4	0.4	.85
Osteoporosis	0.4	0.4	<.99
Stroke	0.5	0.5	.86
Depression	3.4	3.7	.19
Anxiety	4.4	4.9	.06
Diabetes	4.2	4.6	.07
Pregnancy or delivery	1.6	1.4	.19
<b>Type of industry, %</b>			
Oil and gas extraction, mining	1.5	1.4	.54
Manufacturing, durable goods	26.3	27.3	.07
Manufacturing, nondurable goods	18.8	18.2	.19
Transportation, communications, utilities	29.9	29.3	.26
Retail trade	0.0	0.0	...
Finance, insurance, real estate	8.1	8.5	.26
Services	14.8	14.7	.86
Unknown	0.6	0.7	.64

<sup>a</sup>t Tests were conducted on continuous variables; z tests for equality of proportions were conducted on dichotomous variables.  
Some category totals may not sum to 100 due to rounding.

(Charlson Comorbidity Index and diagnoses of cancer, hypertension, heart disease, osteoarthritis, osteoporosis, stroke, depression, anxiety, diabetes, and pregnancy), as well as index year and type of industry. Although matching of patients with vs without disease is a different application of propensity score matching, it has been used in other published studies.<sup>8-10</sup> Matching was performed using nearest neighbor 1:1 with caliper, which was defined as one-fourth of the estimated standard errors of propensity scores. Three sets of propensity score matching were conducted as follows: (1) for all patients with medical, pharmacy, and productivity data to examine their direct costs; (2) for a subset of patients with absence eligibility to examine absence days and associated cost; and (3) for a subset of patients with short-term disability eligibility to examine short-term disability days and associated cost.

Descriptive analyses were conducted to report the means and standard deviations for continuous variables and the number and percentage of patients for categorical variables. Statistical tests

(t test for continuous variables and z test for equality of proportions on dichotomous variables) were performed to compare patients with vs without asthma. Because imbalances in some demographic and clinical characteristics may remain after propensity score matching,

**Statistical Analysis**

Propensity score matching of patients with vs without asthma was conducted using demographic characteristics (eg, age, sex, geographic region, and plan type) and clinical characteristics

multivariate analysis was conducted on the matched samples to examine the marginal effect of asthma on direct and indirect costs. In addition, multivariate regression on matched samples produces more efficient estimators,<sup>11,12</sup> as results tend to converge after multivariate regressions regardless of propensity score-matching type.<sup>11</sup> Generalized linear models with log link and gamma distribution were estimated for direct healthcare expenditures (total and components of cost) and indirect costs associated with absence or short-term disability. Gamma distribution was selected over gaussian distribution based on the results from Park tests. Ordinary least squares models were estimated on the numbers of absence days and short-term disability days. Marginal effects of asthma on costs and days lost from work were calculated as the estimated difference in outcomes from changing the dichotomous variable representing the presence of asthma from 0 to 1 (0 without asthma and 1 with asthma) and holding all other explanatory variables constant at their mean values.

**Table 2.** Unadjusted Direct Medical Costs and Utilization Among Patients With vs Without Asthma

Variable	Patients With Asthma (n = 13,379)	Patients Without Asthma (n = 13,379)	Difference <sup>a</sup>
<b>Direct medical costs, mean (SD), \$</b>			
Hospitalizations	1143 (7864)	710 (6577)	433
ED visits	262 (795)	103 (482)	159
Physician office visits	574 (512)	268 (390)	306
Outpatient prescriptions	1783 (2653)	692 (1582)	1091
<b>Total</b>	<b>3762</b> (8994)	<b>1773</b> (7049)	<b>1988</b>
<b>Utilization</b>			
With ≥1 hospitalizations, No. (%)	991 (7.4)	731 (5.5)	1.9%
With ≥1 ED visits, No. (%)	3747 (28.0)	1851 (13.8)	14.2%
Physician office visits, mean (SD)	6.88 (5.81)	3.15 (3.90)	3.73
Outpatient prescriptions, mean (SD)	21.45 (20.16)	9.10 (13.18)	12.35

ED indicates emergency department.  
<sup>a</sup>P < .001 for all. *t* Tests were conducted on continuous variables; *z* tests for equality of proportions were conducted on dichotomous variables.

## RESULTS

### Sample Size

A total of 705,732 patients with asthma aged 18 to 64 years were identified in the Commercial Database, and 192,993 of them (27.3%) had no COPD or emphysema and had been continuously enrolled with pharmacy and medical benefits for 12 months before and 12 months after the index date. A total of 3,181,834 patients without asthma met the continuous enrollment and inclusion criteria for the study.

Of 192,993 patients with asthma, 13,379 had productivity data (absenteeism, short-term disability, and workers' compensation). These patients were matched with 13,379 controls. Of 13,379 patients with asthma, 3453 were full-time employees with absence eligibility (may or may not have short-term disability or workers' compensation eligibility), and 8497 were full-time employees with short-term disability eligibility (may or may not have absence or workers' compensation eligibility).

These patients were separately matched from a control cohort comprising 13,379 patients. Patients who were excluded from absence or short-term disability analysis were patients with workers' compensation but without absence or short-term disability eligibility. These patients were not included in the analysis of indirect costs because asthma is not a work-related injury. A flow chart of patient selection is shown in the **Figure**.

### Demographic and Clinical Characteristics

After propensity score matching, patients with vs without asthma had similar demographic and clinical characteristics except that patients with asthma had a significantly higher Charlson Comorbidity Index and less hypertension (**Table 1**). The mean age among cases and controls was 42.2 years. The dominant health plan types were preferred provider organizations and point-of-service plans in both cohorts.

### Direct Healthcare Costs and Utilization

Descriptive analysis showed that total costs and cost components for patients with asthma were significantly higher than those for patients without asthma in the 12-month follow-up period (**Table 2**). Total medical costs were significantly higher by \$1988 for patients with asthma vs patients without asthma (\$3762 vs \$1773, *P* < .001). Inpatient costs were \$433 higher (\$1143 vs \$710), emergency department costs were \$159 higher (\$262 vs \$103), outpatient costs were \$306 higher (\$574 vs \$268), and outpatient prescription costs were \$1091 higher (\$1783 vs \$692) for patients with asthma vs patients without asthma (*P* < .001 for all). Utilization was also significantly higher for patients with asthma compared with controls.

■ **Table 3.** Unadjusted Workdays Lost and Associated Indirect Costs Due to Absence and Short-Term Disability Among Patients With vs Without Asthma

Variable	Patients With Asthma	Patients Without Asthma	Difference	P Value <sup>a</sup>
<b>Patients With Absence Eligibility</b>	<b>(n = 3453)</b>	<b>(n = 3453)</b>		
Patients reporting any absence, No. (%)	2879 (83.4)	2870 (83.1)	0.3%	.77
Workdays lost due to absence, mean (SD)	25.1 (20.5)	23.9 (21.5)	1.2	.01
Associated indirect costs, mean (SD), \$	3853 (3226)	3687 (3502)	166	.04
<b>Patients With Short-Term Disability Eligibility</b>	<b>(n = 8497)</b>	<b>(n = 8497)</b>		
Patients reporting any short-term disability, No. (%)	1227 (14.4)	782 (9.2)	5.2%	<.001
Workdays lost due to short-term disability, mean (SD)	6.4 (24.7)	4.2 (19.2)	2.2	<.001
Associated indirect costs, mean (SD), \$	719 (2812)	471 (2224)	248	<.001

<sup>a</sup>t Tests were conducted on continuous variables; z tests for equality of proportions were conducted on dichotomous variables.

### Indirect Costs and Days Lost

Compared with the matched cohort without asthma, patients with asthma on average experienced 1.2 more absence days (25.1 vs 23.9,  $P = .01$ ) and 2.2 more short-term disability days (6.4 vs 4.2,  $P < .001$ ) during the 12-month follow-up period; this translated into \$166 (\$3853 vs \$3687,  $P = .04$ ) and \$248 (\$719 vs \$471,  $P < .001$ ) more in indirect costs associated with absence and short-term disability, respectively, assuming 75% of wage rates for short-term disability days (Table 3). Indirect costs associated with short-term disability were estimated to be \$165 and \$331 higher for patients with asthma if short-term disability paid 50% and 100% of wage rates, respectively.

### Multivariate Regression Analysis

After adjusting for all characteristics, asthma increased total medical costs by \$1785, inpatient costs by \$322, emergency department costs by \$141, outpatient costs by \$294, and pharmacy costs by \$1029 ( $P < .001$  for all). Asthma increased absence days by 1.1 days per year ( $P = .02$ ) and short-term disability days by 2.2 days per year ( $P < .001$ ). Asthma increased indirect costs associated with absence and short-term disability by \$191 per year ( $P = .007$ ) and \$172 per year ( $P < .001$ ), respectively. In the scenario where indirect costs associated with short-term disability were calculated using 50% and 100% of wage rates, indirect costs associated with short-term disability increased by \$115 per year and \$229 per year, respectively ( $P < .001$  for both).

## DISCUSSION

Using a large administrative claims database from 2002 to 2006 that is representative of the US population working for large self-insured employers, this study used a matched cohort to examine the incremental direct and indirect costs associat-

ed with asthma. Patients with asthma had significantly higher direct and indirect costs than matched patients without asthma. During a 1-year period, patients with asthma had \$1785 higher mean total medical expenditures and experienced 1.1 more absence days and 2.2 more short-term disability days, which translated into \$191 and \$172 more in absenteeism and short-term disability costs, respectively.

During a 12-month follow-up period, the mean annual medical costs of patients with asthma were \$3762, which lies between the \$2697 estimated by Cisternas et al<sup>4</sup> (1998-1999 data) and the \$4424 estimated by Birnbaum et al<sup>5</sup> (1998 data). However, it is substantially lower than the \$6452 estimated by Colice et al<sup>6</sup> (2004 data). In our study, drug costs represented a significant portion of direct costs. They accounted for about 47% (\$1783) of direct costs compared with the 33% (\$2127) estimated by Colice et al and the 30% (\$1325) estimated by Birnbaum et al. According to Cisternas et al, drug costs accounted for 60% (\$1605) of direct costs. The incremental direct costs associated with asthma herein (\$1785) were lower than the \$4412 estimated by Colice et al and the \$2839 estimated by Birnbaum et al.

This study found that 83.4% of eligible patients with asthma used absence days and that 14.4% of eligible patients with asthma used short-term disability days. Frequency of asthma symptoms was not captured in the claims database, although a study<sup>13</sup> that assessed economic and social burden among patients with asthma in California found a strong relationship between work loss and frequency of asthma symptoms. The investigators observed that the percentage of patients with asthma missing at least 1 week of work during a 1-year period was more than twice as high among those who experienced daily or weekly asthma symptoms compared with those who experienced symptoms less than once a month.<sup>3</sup> The studies by Cisternas et al<sup>4</sup> and by Colice et al<sup>6</sup> support this finding.

The absolute difference in absence days was not large between asthma cases and controls. The difference translates into

5% more absence days among patients with asthma than among patients without asthma. However, a closer look at absence days showed more absenteeism variation in this study when patients in both groups having absenteeism in the upper 5% are compared. The upper 5% of patients with asthma had at least 48 days of absenteeism, while the upper 5% of patients without asthma had at least 45 days of absenteeism. The variation was much larger for short-term disability days. The upper 5% of patients with asthma had at least 41 short-term disability days, while the upper 5% of patients without asthma had only a minimum of 29 short-term disability days. Compared with other patients, the top 5% of patients with asthma seemed more different with regard to work loss. This is the group that should be targeted by employers in their disease management programs.

On average, patients with asthma incurred a total of \$4572 for indirect costs in this study, with \$3853 associated with absence and \$719 associated with short-term disability. This was much higher than the \$1732 estimated by Cisternas et al<sup>4</sup> for indirect costs, which can most likely be attributed to the fact that Cisternas et al measured asthma-related indirect costs, while our study examined all-cause indirect costs. The study by Cisternas et al also excluded all patients older than 50 years, which may result in a less costly population. However, our estimated incremental indirect costs of \$363 (\$191 for absenteeism plus \$172 for short-term disability) are modestly lower than \$486, the portion of asthma-related indirect costs estimated by Cisternas et al that is directly comparable. In the study by Colice et al,<sup>6</sup> total mean indirect costs for patients with asthma were \$1607, with \$1291 in absenteeism and \$316 in short-term disability during a 1-year follow-up period. Their indirect costs may have been lower because of a younger (mean age, 29.6 years) and healthier study cohort compared with ours (mean age, 42.2 years). This hypothesis cannot be confirmed because Colice et al did not report the mean comorbidity burden of their study population. Our \$363 incremental indirect costs from absenteeism and short-term disability among patients with asthma were lower than the \$924 estimated by Colice et al but were close to the estimate of \$426 by Birnbaum et al.<sup>5</sup>

There are several limitations that should be considered when interpreting these study findings. First, the overall study sample included patients from large self-insured employers, and their costs may not reflect costs of those covered by Medicaid, costs of those who have no insurance, or indirect costs of patients from small employers. Second, workdays lost in the follow-up period were not required to be directly associated with asthma. Because the actual cost data were not complete in the database used in this study, indirect costs were imputed by multiplying days lost using wage rates from the Bureau of Labor Statistics; therefore, they were not the realized costs of the study

patients. Because the Bureau of Labor Statistics has a mixture of small and large employers and because the mean wage rate is lower for smaller employers than for larger employers,<sup>14</sup> applying the mean wage rates from the Bureau of Labor Statistics in the calculation of indirect costs might underestimate indirect costs for this study population, as patients in MarketScan Research Databases are employees of large employers. In addition, because wage rates vary by industry and by hourly vs salaried workers, having the actual wage rate of each patient would have provided a more accurate estimate of indirect costs. Third, costs of patients with asthma might be underestimated in this study because costs associated with presenteeism or indirect costs for patients who were part-time workers were not included. Also, many patients herein were probably incident patients.

Overall, the estimates obtained in this study are more recent than but comparable to those in previous studies. Considering differences in study designs and methods among other studies, the cost estimates from this study seem reasonable. The results are generalizable to a much larger employed population compared with the few studies that have focused on a smaller study population.

In conclusion, patients with asthma had significantly higher direct and indirect costs than matched patients without asthma. Disease management programs and treatments that prevent or reduce asthma symptoms may have a beneficial effect on medical costs and work absenteeism.

**Author Affiliations:** GlaxoSmithKline (RS, CRC), Research Triangle Park, NC; and Thomson Reuters (XS, JAA, BCC), Washington, DC.

**Funding Source:** This study was funded by GlaxoSmithKline.

**Author Disclosures:** Drs Shenolikar and Cantrell report being employed by and owning stock in GlaxoSmithKline. The other authors (XS, JAA, BCC) report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

**Authorship Information:** Concept and design (RS, XS, JAA, BCC, CRC); analysis and interpretation of data (RS, XS, JAA, BCC); drafting of the manuscript (RS, XS, JAA); critical revision of the manuscript for important intellectual content (RS, XS, JAA, BCC, CRC); statistical analysis (BCC); obtaining funding (CRC); and supervision (CRC).

**Address correspondence to:** Rahul Shenolikar, PhD, GlaxoSmithKline, c/o 5 Moore Dr, Durham, NC 27709. E-mail: rahul.a.shenolikar@gsk.com.

## REFERENCES

1. **National Heart, Lung, and Blood Institute.** Guidelines for the diagnosis and treatment of asthma (EPR-3). <http://www.nhlbi.nih.gov/guidelines/asthma/>. Published 2006. Accessed May 14, 2009.
2. **Akinbami L.** Asthma prevalence, health care use and mortality: United States, 2003-05. Hyattsville, MD: National Center for Health Statistics. <http://www.cdc.gov/nchs/data/hestat/asthma03-05/asthma03-05.htm#fig3>. Published 2006. Accessed October 4, 2009.
3. **Asthma and Allergy Foundation of America.** Asthma facts and figures. <http://www.aafa.org/display.cfm?id=9&sub=42>. Accessed July 22, 2010.
4. **Cisternas MG, Blanc PD, Yen IH, et al.** A comprehensive study of the direct and indirect costs of adult asthma. *J Allergy Clin Immunol.* 2003; 111(6):1212-1218.
5. **Birnbaum HG, Berger WE, Greenberg PE, et al.** Direct and indirect costs of asthma to an employer. *J Allergy Clin Immunol.* 2002;109(2): 264-270.

- 6. Colice G, Wu EQ, Birnbaum H, Daher M, Marynchenko MB, Varghese S.** Healthcare and workloss costs associated with patients with persistent asthma in a privately insured population. *J Occup Environ Med.* 2006;48(8):794-802.
- 7. US Census Bureau.** Current population survey, 2006 annual social and economic supplement. <http://www.nber.org/cps/cpsmar06.pdf>. Published 2006. Accessed April 20, 2011.
- 8. Short PF, Moran JR, Punekar R.** Medical expenditures of adult cancer survivors aged <65 years in the United States [published online ahead of print December 23, 2010]. *Cancer.* <http://onlinelibrary.wiley.com/doi/10.1002/cncr.25835/pdf>. Accessed February 4, 2011.
- 9. Campbell RC, Sui X, Fillippatos G, et al.** Association of chronic kidney disease with outcomes in chronic heart failure: a propensity-matched study. *Nephrol Dial Transplant.* 2009;24(1):186-193.
- 10. Aronow WS, Ahmed MI, Ekundayo OJ, Allman RM, Ahmed A.** A propensity-matched study of the association of peripheral arterial disease with cardiovascular outcomes in community-dwelling older adults. *Am J Cardiol.* 2009;103(1):130-135.
- 11. Baser O.** Too much ado about propensity score models? comparing methods of propensity score matching. *Value Health.* 2006;9(6):377-385.
- 12. Rubin DB, Thomas N.** Combining propensity score matching with additional adjustments for prognostic covariates. *J Am Stat Assoc.* 2000;95(450):573-585.
- 13. Meng YY, Babey SH, Hastert TA, Lombardi C, Brown ER.** Uncontrolled asthma means missed work and school, emergency department visits for many Californians. *Policy Brief UCLA Cent Health Policy Res.* 2008;(PB2008-2):1-8. <http://www.healthpolicy.ucla.edu/pubs/publication.asp?pubID=252#download>. Accessed May 14, 2009.
- 14. Bureau of Labor Statistics.** Economic news release: table 8: private industry, by establishment employment size. <http://www.bls.gov/news.release/ecec.t08.htm>. Accessed March 11, 2010. ■