

# Direct and indirect costs of asthma to an employer

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Asthma, rhinitis,  
other respiratory  
diseases

**Background:** Asthma is a chronic inflammatory condition of the airways that has a significant effect on the use of health care resources.

**Objective:** This study is the first of its kind to estimate the overall cost of asthma to a major employer in the United States and to profile the nature of the asthma expenses.

**Methods:** The annual per capita cost of asthma was determined for beneficiaries of a major employer by analyzing medical, pharmaceutical, and disability claims data. The incremental cost of asthma was determined by using a case-control method matching asthmatic patients to individuals with no record of asthma treatment.

**Results:** The use of health care services, as well as the rate of disability, was substantially higher among asthmatic patients than among control subjects. Annual per capita employer expenditures for asthmatic patients were approximately 2.5 times those for control subjects (\$5385 vs \$2121, respectively). Among asthmatic employees with disability claims, total costs were approximately 3 times higher than those among disability claimants in the employee control sample (\$14,827 vs \$5280). For asthmatic employees, wage-replacement costs for workdays lost as a result of disability and sporadic absenteeism (40%) accounted for almost as much as did medical care (43%).

**Conclusion:** Failure to account fully for the broader consequences of asthma in terms of indirect and comorbid treatment costs would result in a significant underassessment of the cost of asthma to an employer. (*J Allergy Clin Immunol* 2002;109:264-70.)

**Key words:** Asthma, costs, economics, claims data, health outcomes, workplace burden, work loss, pharmacoeconomics

Asthma is a chronic inflammatory condition of the airways that has a significant effect on the use of health care resources. In 1995, an estimated 14.9 million people in the United States had the disease, causing over 1.5 million emergency department visits, approximately 500,000 hospitalizations, and over 5500 deaths.<sup>1</sup> The estimated direct and indirect costs for this disease totaled \$12.7 billion in

## Abbreviation used

HMO: Health maintenance organization

1998.<sup>2</sup> In addition, asthma is one of the most common causes of disability among the workforce.<sup>3</sup>

The treated prevalence of asthma is 45 to 60 per 1000 persons, with a higher rate among African American subjects, Hispanic subjects, children, and women.<sup>4</sup> Several studies have demonstrated the significant adverse economic consequences of asthma to patients<sup>1,5-8</sup> and their caregivers.<sup>9</sup> Consequently, it is not surprising that asthma also is a major concern for payers.<sup>10</sup> However, although the asthma-outcomes literature has burgeoned in recent years,<sup>11-13</sup> none of this research provides a comprehensive profile of its workplace burden.

Most previous studies on the direct treatment costs of asthma rely on epidemiologic questionnaires and use national health statistics to present cost-of-illness results at a national level. Weiss et al<sup>7</sup> developed a widely followed methodology to calculate national estimates for asthma that involves multiple data sources. It involves a cost model that uses national prevalence statistics and imputed costs, rather than observed patient-specific data regarding asthma status and costs. A number of studies have followed this approach (generally using data for the early 1990s) and have generated annual asthmatic patient costs of approximately \$500 per patient.<sup>5,9,14</sup> Although informative, this approach is limited by its reliance on self-reported data, together with assigned costs per day, per visit, or per prescription assumptions, as opposed to actual cost data.

In contrast, a few studies have used actual (ie, observed) patient-specific claims data to identify asthmatic patients and to quantify the cost of their care. One study estimated that 1993 annual direct medical charges for asthma treatment were \$467 per asthmatic member of 4 health maintenance organizations (HMOs).<sup>6</sup> A second study of patients of a large HMO found that the 1992 cost of treating asthmatic children was \$615 and that there are larger non-asthma-related direct medical expenses in the asthmatic population than among control subjects.<sup>15</sup> Another found that annual asthma-specific treatment charges in a managed care setting were \$927 per asthmatic patient in the period from 1997 to 1998.<sup>16</sup> The literature also includes research on the pharmacoeconomic outcomes and cost-effectiveness of various asthma treat-

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ments.<sup>17</sup> Although most such studies have relied on clinical trial data, one recent cost-effectiveness study using 1996 to 1998 claims data estimated \$4000 in annual health care costs for asthmatic patients and asthma-specific treatment costs of up to \$1000.<sup>18</sup>

In addition, there is research on the indirect costs of asthma, including the burden attributable to mortality, workforce participation, and work cutback.<sup>5,7,9,11,19</sup> From a disability perspective, asthma is one of the most common conditions in the working population and is the fifth most common cause of workplace limitation.<sup>20</sup> One study using survey data found that 10% of asthmatic patients treated by pulmonary specialists attributed asthma as a cause of partial work cessation, and an additional 7% attributed asthma as the cause of complete work cessation.<sup>3</sup>

## METHODS

This study used a case-control analysis to develop an economic profile of asthma care from the perspective of a major employer in the United States. The question addressed here is how much asthmatic patients incur in incremental costs compared with that incurred by otherwise similar patients who do not have asthma. It accounts for both the direct costs (ie, treatment covered by the employer's medical and prescription drug-benefit programs) and indirect costs (ie, payments for missed work days covered by the employer's disability and sick-leave program).

## Data

The data source for this study is an administrative claims database with linked individuals' records derived from distinct parts of one corporate benefits system that document payments for these benefits. The data consist of 1996 to 1998 health care (ie, medical and prescription) claims for employees, spouses, dependents, and retirees and disability claims for beneficiaries of a national Fortune 100 corporation with comprehensive health insurance and a predominantly unionized workforce. In addition, for each beneficiary, the data include various demographic information. In 1998, over 100,000 such beneficiaries were enrolled across the nation in one of this company's managed indemnity insurance plans. During this period, plan benefits were essentially constant. Data on patients in HMOs (who accounted for approximately 20% of enrollees) are not available. Because medical claims for Medicare patients are incomplete in the employer database, patients over the age of 65 years are excluded from the sample.

Health care claims expenditures paid by the employer include information on the date of service and the nature of the ailment. Detailed diagnosis (International Classification of Diseases, 9th Revision), procedure (current procedural terminology), and pharmacy (National Drug Code) information are available. Although the specific claims data used in this analysis have not been validated in medical chart reviews, they do reflect actual employment records and payments. Although clinical measures are missing, the data set provides a valuable source of economic information about real-world behavior.<sup>21-29</sup>

In the context of this study, direct and indirect costs are actual cash outlays by the employer. Direct costs refer to average (ie, mean) payments by the employer (ie, the insurer) to providers for health care services. Indirect costs refer to payments by the employer for disability and medically related absences. Such payments need not reflect the true societal opportunity cost of the resources used. Our approach does not capture, for example, patient out-of-pocket costs for deductibles and copayments, other nonmedical costs that may be incurred, or lost income if employees drop out of the workforce.

The methods for using the administrative data are similar to the approach taken by Burton and Conti,<sup>30,31</sup> who used a data warehouse to analyze the workplace effects of a range of illnesses. However, our data do not include measures of on-the-job productivity. Work-loss costs refer here to employer payments for the sum of disability days plus imputed illness-based absence time on the basis of days when medical care was provided.<sup>32,33</sup> In 1998, approximately 85% of all employees were covered by the employer's disability benefit plan.

## Identification of asthmatic patients

Using procedures similar to those used in previous asthma-claims data research,<sup>13</sup> we identified 9602 patients under the age of 65 years with one or more medical or disability claims (International Classification of Diseases, 9th Revision: 493) for asthma in 1996 to 1998 who were enrolled in the employer's benefit plan in each of the 3 years. The prevalence of asthma in this employer population, as well as the predominance of children and women, is consistent with population estimates.<sup>4</sup> To eliminate patients without chronic asthma, we restricted our sample to patients who had at least one asthma medical claim in each of 2 or more years.

## Case-control design

Because the overall population covered by the employer's benefit plan was older than the average general asthmatic population and therefore likely to be more costly, we compared the costs of asthmatic patients with those of matched control subjects who were otherwise demographically and occupationally similar (Fig 1). We excluded from the potential control group those patients with one or more claims for asthma in 1996 to 1998 but otherwise used the same inclusion criteria.

To identify the case control subjects on a one-to-one basis, we matched each asthmatic patient and, in effect, used a stratified random-sample approach. Patients in the control group are stratified along 5 dimensions (ie, age, sex, job classification, health plan, and residential zip code). Within each stratum, a beneficiary of the employer who had no claims for asthma treatment in 1996 to 1998 was randomly picked as the match for the asthmatic patient who falls within the same stratum. Thus, these matched individuals are of the same age, sex, job classification, health plan, and residential zip code as the associated asthmatic patient. We assume that these latter individuals would, on average, have been otherwise similar to the asthmatic patients in unobserved variables, such as health condition, lifestyle, attitude toward seeking medical care, and treatment by health care providers. These matched individuals constituted an age-matched approximate control group, suggesting the appropriate baseline levels of health care and disability costs unrelated to asthma, to the extent that these unobserved variables are randomly distributed among the 2 groups.

We matched 96% of asthmatic patients with control subjects. The remaining unmatched patients consisted of a greater proportion of female patients (78%) than the matched group of asthmatic patients (55%) but were otherwise demographically similar. Further details of the control group selection process are presented elsewhere.<sup>33</sup> In summary, we were able to closely match 3387 asthmatic patients (asthmatic patient research sample) with an identical number of control subjects. Because further relaxing the matching criteria could yield control subjects not directly comparable with asthmatic patients and would hamper the controlled nature of the analysis, we eliminated 4% of asthmatic patients for whom close matches were not available.

To support an analysis explicitly focused on the work-loss component of employer costs, we further identified an asthmatic employee sample. The asthmatic employee sample consisted of the subset of 801 employees among the asthmatic patient sample who were actively employed workers eligible for disability benefits.

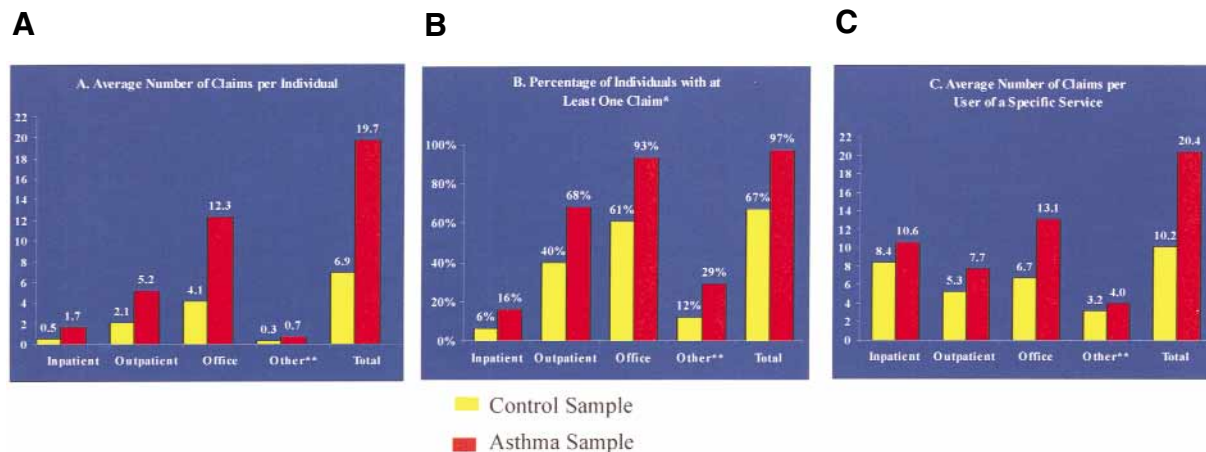


**FIG 1.** 1998 Medical claims per treated asthmatic patient by type of service. *Average* refers to the mean of the observations. SDs for total claims: **A**, 19.9 (23.3) 6.9 (12.3); **C**, 20.4 (23.4) 10.2 (13.8). Medical care does not include prescription drug claims. \*Differences between asthmatic sample and control sample for **A-C**:  $P < .0001$ .  $P$  values were derived with  $t$  tests. \*\*Other includes care at patient's home, nursing-extended care facility, substance abuse treatment facility, independent clinical laboratories, freestanding dialysis facility, or durable medical equipment visits.

**TABLE I.** Demographic characteristics\*

|                 | Employer population | All asthmatic patients | Matched asthmatic patient sample | Matched asthmatic employee sample | Control sample of nonasthmatic employees |
|-----------------|---------------------|------------------------|----------------------------------|-----------------------------------|------------------------------------------|
| No. of persons  | 10% random sample   | 3528                   | 3387                             | 801                               | 801                                      |
| Sex: female (%) | 49                  | 55                     | 55                               | 29                                | 29                                       |
| Employees (%)   | 29                  | 23                     | 24                               | 100                               | 100                                      |
| Age             |                     |                        |                                  |                                   |                                          |
| Mean (SD), y    | 39 (18)             | 35 (19)                | 35                               | 47                                | 47                                       |
| <18 y           | 19%                 | 29%                    | 29%                              | 0%                                | 0%                                       |
| 18-35 y         | 16%                 | 15%                    | 15%                              | 15%                               | 15%                                      |
| 36-45 y         | 16%                 | 15%                    | 15%                              | 25%                               | 26%                                      |
| 46-55 y         | 28%                 | 25%                    | 25%                              | 42%                               | 42%                                      |
| 56-64 y         | 20%                 | 17%                    | 16%                              | 19%                               | 18%                                      |

Differences between employer overall population and asthma samples (both for patient and employee subgroups),  $P < .0001$  (with the exception of ages 18 to 35 and 36 to 45 years,  $P = .1096$ ).  $P$  values were derived from  $t$  tests.

## RESULTS

The demographics of the patients are presented in Table I. The matched asthmatic patients are younger than the employer population (mean age, 35 vs 39 years;  $P < .0001$ ), and a greater percentage are female (55% vs 49%,  $P < .0001$ ). Also, fewer asthmatic patients are employees (23% vs 29%,  $P < .0001$ ). Because the use of services drives health care costs, we first present results on patterns of use.

The pattern of health care use is presented in Fig 1 in terms of the average number of claims per individual for the asthmatic and control samples by type of service for all patients and for users of specific types of service. Fig 1, A, shows the average (ie, mean) number of claims per individual in 1998 for the asthmatic and control samples.

Asthmatic patients have approximately 3 times more medical claims than the average beneficiary in this population (19.7 vs 6.8,  $P < .0001$ ).

This high level of use results from two factors, also shown in Fig 1: the percentage of each of those samples with use of a particular service and, for those patients who used the specific service, the average number of such claims. Fig 1, B, shows that the percentage of asthmatic patients with at least one visit exceeds that for the overall population (97% vs 67%,  $P < .0001$ ). Fig 1, C, shows that the average annual number of claims among users of medical services caused by asthma was 20.5 versus 10.3 for the control sample ( $P < .0001$ ).

The average asthmatic patient was far more likely to consume asthma-related medications than the average

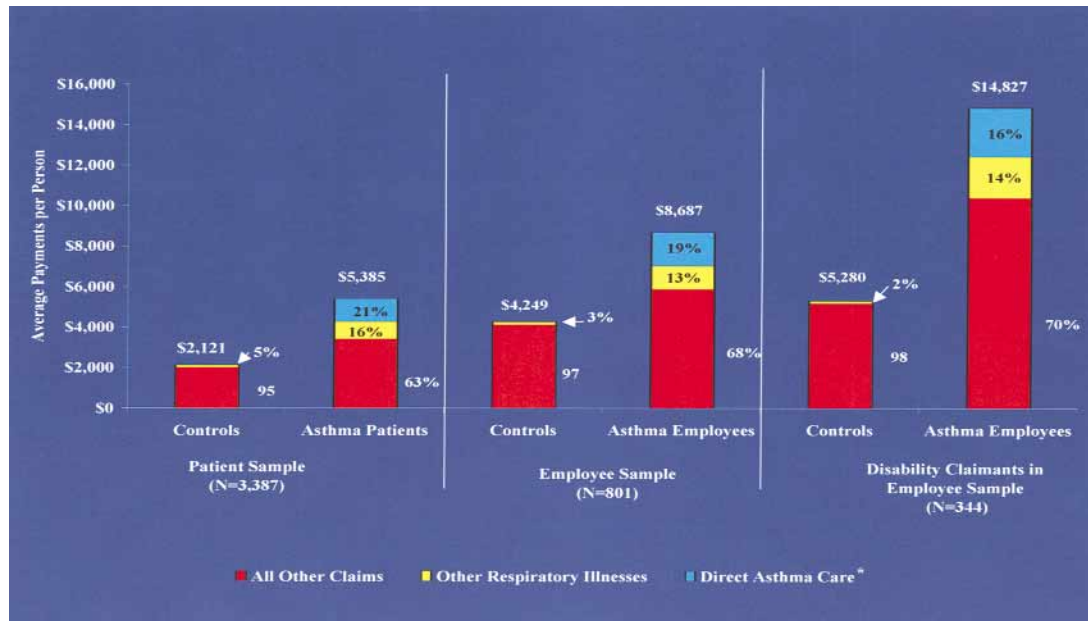


**FIG 2.** 1998 Employer payments for treated asthmatic patients: health care, prescription drug, disability, and absenteeism. SDs: patient sample, see Table II; employee sample, 8687 (10,415) 4249 (8089); disability claimants, 14,827 (12,112) 5280 (9204). Differences between asthmatic patients and control subjects (for all samples):  $P < .0001$ .  $P$  values were derived with  $t$  tests. \*Pharmacy costs associated with direct asthma care include secondary asthma-related prescriptions, which are also used for the treatment of other respiratory diseases.

beneficiary. Among asthmatic patients, 88% used asthma-related medications in 1998 versus 31% among the control group ( $P < .0001$ ). This pattern holds for both primary asthma medications\* and for drugs for related respiratory conditions, which are termed secondary asthma medications.† For example, although 79% of the asthmatic patients filled prescriptions for primary asthma medications, 9% of the control subjects not identified as asthmatic patients also did so ( $P < .0001$ ). This pattern is considered in the “Discussion” section.

Employer costs per asthmatic patient (including spouses, dependents, and retirees under the age of 65 years) for medical, pharmaceutical, and work-loss expenditures are shown in Fig 2. Comparisons are provided for the overall sample of asthmatic patients versus their matched control subjects, as well as for 2 subsamples: all employees and disability claimants. Annual per capita employer expenditures for asthmatic patients were approximately 2.5 times those for control subjects (\$5385 vs \$2121, respectively;  $P < .0001$ ). Among asthmatic employees with disability claims, total costs were approximately 3 times higher than

among disability claimants in the employee control sample (\$14,827 vs \$5280,  $P < .0001$ ). Although treatment for asthma itself accounts for 16% or more of total costs, including costs of treatment for other respiratory illnesses, conditions comorbid to asthma account for an additional 13% or more, depending on which patient group is considered. For example, among asthmatic employees, treatment for asthma and related comorbid conditions accounts for 32% of total costs and for most of the excess costs of asthmatic employees over their matched control subjects.

Table II disaggregates the cost data for health care and work absence, as well as for services for treatment of asthma, other respiratory conditions, and all other care. Medical care cost \$3100 for asthmatic patients, and although it was the largest component of the employer-borne costs of asthma (59%), prescription drugs were the second largest component of costs (25%), followed by work loss (16%). The incremental cost of asthma was \$3265, as measured by the difference between the total annual costs of asthmatic and control patients (including both medical and work-loss costs). However, the cost of direct asthma care (as measured by medical and disability claims with a diagnosis of asthma) was only \$1119. This result reflects that most of the incremental costs imposed by asthmatic patients on this employer were for treatment of nonasthma diagnoses. This result is consistent with the use results reported above. Also, a substantial source of the greater medication costs for the average

\*Primary asthma-related drugs are defined as short-acting  $\beta_2$ -agonists, inhaled corticosteroids, oral corticosteroids, long-acting  $\beta_2$ -agonists, leukotriene modifiers, cromones, methylxanthines, anticholinergics, oral  $\beta_2$ -agonists, and antiasthmatic combinations.

†Secondary asthma-related drugs are defined as upper respiratory combinations, antihistamines, nasal steroids, expectorants, antitussives, and decongestants.

TABLE II. Average annual employer payments: treated asthma patients compared with the control group\*†

|                                  | Asthma patients                                |                                          |                                            |                                        | Control subjects                       |                                            |                               | 1998<br>Incremental<br>costs<br>[8] = [4] – [7] |
|----------------------------------|------------------------------------------------|------------------------------------------|--------------------------------------------|----------------------------------------|----------------------------------------|--------------------------------------------|-------------------------------|-------------------------------------------------|
|                                  | Direct asthma<br>care<br>(ICD-9 493.xx)<br>[1] | Other<br>respiratory<br>illnesses<br>[2] | Other care<br>(all other<br>claims)<br>[3] | All claims<br>[4] = [1] +<br>[2] + [3] | Other<br>respiratory<br>illness<br>[5] | Other care<br>(all other<br>claims)<br>[6] | All claims<br>[7] = [5] + [6] |                                                 |
| Health care costs (per patient)‡ |                                                |                                          |                                            |                                        |                                        |                                            |                               |                                                 |
| Medical                          | \$526                                          | \$703                                    | \$1871                                     | \$3100                                 | \$88                                   | \$1094                                     | \$1182                        | \$1917                                          |
| Pharmacy‡                        | \$479                                          | —                                        | \$846                                      | \$1325                                 | —                                      | \$403                                      | \$403                         | \$922                                           |
| Subtotal                         | \$1004                                         | \$703                                    | \$2717                                     | \$4424                                 | \$88                                   | \$1497                                     | \$1585                        | \$2839                                          |
| Work absence costs (per patient) |                                                |                                          |                                            |                                        |                                        |                                            |                               |                                                 |
| Absenteeism                      | \$51                                           | \$93                                     | \$272                                      | \$416                                  | \$18                                   | \$182                                      | \$200                         | \$216                                           |
| Disability                       | \$64                                           | \$57                                     | \$424                                      | \$545                                  | \$5                                    | \$331                                      | \$336                         | \$210                                           |
| Subtotal                         | \$115                                          | \$149                                    | \$697                                      | \$961                                  | \$23                                   | \$512                                      | \$535                         | \$426                                           |
| Total costs (SD)                 | \$1119<br>(\$2462)                             | \$852<br>(\$5495)                        | \$3414                                     | \$5385<br>(\$10,745)                   | \$111<br>(\$2048)                      | \$2010                                     | \$2121<br>(\$6541)            | \$3265                                          |

ICD-9, International Classification of Diseases, 9th Revision.

\*Average refers to the mean of the observations; SDs are reported for total costs other than the residual-calculated numbers.

†Differences between asthmatic patients and control subjects:  $P < .0001$ .  $P$  values were derived with  $t$  tests ( $n = 3387$ ).

‡Pharmacy costs associated with direct asthma care include secondary asthma-related prescriptions, which are also used for the treatment of other respiratory illnesses.

asthmatic patient (which at \$1325 were approximately 3 times that for the control subjects, \$403;  $P < .0001$ ) involved claims for non-asthma-related medications. A similar analysis for employees found that wage-replacement costs accounted for almost as much in employer costs (40%) as did medical care (43%). This pattern is due primarily to the fact that almost twice as many employees had a disability claim as did their matched control subjects (44% vs 23%,  $P < .0001$ ).

## DISCUSSION

This analysis demonstrates the financial burden of asthma to this employer. Resource use by asthmatic patients is substantial, primarily because of unusually high rates of disability and absenteeism associated with this illness and care for comorbid conditions. From a use perspective, 2 important features of asthma are apparent. First, use of health care services is substantially higher among asthmatic patients than among the overall population. Second, asthma-specific claims account for a relatively small percentage of asthmatic patients' use. Overall, approximately one in 6 claims are for asthma-specific services.

The results emphasize that most (ie, 65%) of the employer's incremental expenditures incurred for asthmatic patients accrue from the direct and indirect costs that are not asthma specific, which is consistent with results reported elsewhere.<sup>15,34</sup> Indeed, the non-asthma-related direct medical expenses are larger in the asthmatic population than among the control subjects (eg, subtracting the direct asthma costs of patients in Table II (\$1004) yields nonasthma direct costs of \$3420 compared with control subject medical costs of \$1585). This result is similar to that found elsewhere.<sup>18</sup> Consequently, failure to properly account for the broader consequences of asthma in terms of indirect costs would result in a significant underassessment of the cost of asthma.

Given the role of medications in treating asthma, the cost of prescription drugs by asthmatic patients is not surprising. Although the cost of asthma-specific medications was approximately the same as the overall medication cost of the control subjects, the nonasthma medications used by asthmatic patients cost approximately twice that of all the medications of the control subjects. In other words, the high cost of medications by asthmatic patients arises more from their use of non-asthma-related than asthma-related medications. This use of asthma-related drugs by nonasthmatic patients may reflect various factors, including use of respiratory agents by nonasthmatic patients for related conditions (eg, bronchitis), treatment of an asthmatic before the observation window, and lack of explicit diagnosis for asthma on the claim, which would reflect undercoding of asthma in this group.

It is noteworthy that among both asthmatic patients and the overall population, pharmaceutical costs accounted for approximately one fourth of total health care costs. This finding is consistent with results reported by other investigators.<sup>6,12</sup> Given the visibility of prescription drug costs in the scientific literature and the popular press, it is informative to recognize that the share of the employer's overall health care bill that is accounted for by prescription drugs is the same for both asthmatic and control patients.

The cost estimates reported here of the annual health care cost of asthma treatment (approximately \$1000 per patient) are consistent with those in the claims-data literature.<sup>6,15,18</sup> However, the estimates are considerably higher than those implicit in aggregate estimates that use a cost-of-illness methodology.<sup>5,7,9,14</sup> In part, the additional costs are due to the use of actual claims, rather than imputed costs, although we recognize that the results here are not directly comparable with those of studies of the general population. In addition to using

measures of actual payments by the employer, the claims data allow identification of claims for comorbid conditions, as well as employer payments for work loss. Because the data are for an employed population, they may in fact underestimate the costs incurred by the many low-income, uninsured, or inner-city asthmatic patients. Such individuals without private insurance may receive inadequate treatment, which can result in more frequent exacerbations, greater use of emergency departments, and increased costs.

Because this study uses claims data, the findings are subject to the usual limitations of administrative data sets (eg, inaccurate reporting, incomplete reporting, or both of diagnoses and incomplete assembly of claims).<sup>15,35</sup> Furthermore, to the extent that unobserved, nonmatched variables are not randomly distributed between the asthmatic and control groups (eg, smokers may have a higher probability of asthma and lung cancer), a portion of the cost differential between asthmatic patients and control subjects may be unrelated to asthma. Unfortunately, the data do not allow us to quantify this effect because claims do not include information on lifestyle or overall health conditions, which is a topic for future research. Also, it would be useful to analyze the effect of differences in severity of asthma. Unfortunately, one of the limitations of claims data is the absence of clinical detail appropriate to measure the severity of asthma.

From a statistical perspective, although this initial exploration of asthma's economic effect on the workforce is limited to descriptive measures, future research should consider development of multivariate models that would determine the degree to which asthma status predicts costs. As a first step in the development of such models and to test the sensitivity analysis of the results, we estimated a regression model (using generalized least squares) that fit total cost as a function of asthma status, as well as age, sex, employment status, zip code of residence, and health plan. The regression results on total cost are consistent with the descriptive statistics. The coefficient on the asthma variable was within 2% of the descriptive statistics (\$3341 vs \$3265) and was statistically significant ( $P < .0001$ ). By including various comorbidities in future multivariate models, it also may be possible to consider the cost associated with levels of severity of illness.

Although this article has begun to tell the story of the cost of asthma from the employer's perspective, it addresses only a subset of cost categories. For example, work-loss absence costs are included for both imputed medically related absenteeism but do not capture short-term absences for which there are no claims. They reflect only a fraction of the employer's total opportunity cost for workforce disruptions. Other likely workplace costs include reduced productivity, administrative and training expenses for replacement workers, and sporadic days missed.<sup>36</sup> Nor have we considered the loss of productivity associated with illness when the employee remains at work. There are a growing number of productivity-based investigations that rely on archival data gathered at the

employee level, but such studies have not yet investigated asthma.<sup>30</sup> Another cost not considered involves caregiver costs of asthmatic patients. Both issues of productivity loss and caregiver costs warrant further research. Similarly, although we have focused on costs from an employer's perspective, many asthmatic patients are not among this group. A further consideration, which this analysis does not capture, is the cost to the patient not borne by the employer, such as those that arise from coinsurance and deductible payments.

This analysis demonstrates the financial burden of asthma from an employer's perspective. Resource use by asthmatic patients is substantial, primarily because of unusually high rates of disability and absenteeism associated with this illness and care for comorbid conditions. Failure to account fully for the consequences of asthma in terms of indirect and comorbid costs would result in a significant underassessment of the cost of asthma to an employer. Although this study addresses only a subset of cost categories that contribute to the overall cost of asthma, it does provide a framework for further research to explore the role of comorbidities, severity of disease, productivity loss, and other factors that may further affect the cost of asthma.

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