

# Costs of asthma in the United States: 2002-2007

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**Background:** The economic burden of asthma is an important measure of the effect of asthma on society. Although asthma is a costly illness, the total cost of asthma to society has not been estimated in more than a decade.

**Objective:** The purpose of this study is to provide the public with current estimates of the incremental direct medical costs and productivity losses due to morbidity and mortality from asthma at both the individual and national levels for the years 2002-2007.

**Methods:** Data came from the Medical Expenditure Panel Survey. Two-part models were used to estimate the incremental direct costs of asthma. The incremental number of days lost from work and school was estimated by negative binomial regressions and valued following the human capital approach. Published data were used to value lives lost with an underlying cause of asthma.

**Results:** Over the years 2002-2007, the incremental direct cost of asthma was \$3,259 (2009 dollars) per person per year. The value of additional days lost attributable to asthma per year was approximately \$301 for each worker and \$93 for each student. For the most recent year available, 2007, the total incremental cost of asthma to society was \$56 billion, with productivity losses due to morbidity accounting for \$3.8 billion and productivity losses due to mortality accounting for \$2.1 billion.

**Conclusion:** The current study finds that the estimated costs of asthma are substantial, which stresses the necessity for research and policy to work toward reducing the economic burden of asthma. (*J Allergy Clin Immunol* 2011;127:145-52.)

**Key Words:** Asthma, expenditures, Two-part model, direct cost, productivity losses, mortality losses

Asthma is a chronic, sometimes debilitating disorder of the airways characterized by recurrent symptoms of coughing (particularly at night), wheezing, chest tightness, and difficulty

## Abbreviations used

GLM: Generalized linear model  
ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification  
MEPS: Medical Expenditure Panel Survey

breathing. Although asthma affects persons of all ages, there is a higher prevalence of asthma among children younger than 18 years (9.3%) than among adults (7.3%).<sup>1</sup> Asthma affects patient's lives and those of their families, including their quality of life, productivity at work and school, and health care use, and can even result in death. The economic burden of the disease is a crucial measure of the societal effect of the disease for policy makers in setting priorities for public health programs.

There have been numerous studies on the costs of asthma internationally<sup>2-12</sup> and in the United States on the costs of adult<sup>13-16</sup> and pediatric<sup>17-23</sup> asthma. However, there have been few studies and reports<sup>24-28</sup> that have estimated direct costs and productivity losses due to asthma for persons of all ages from a societal perspective. A frequently cited study, conducted by Weiss et al<sup>25</sup> in 1992, estimated the cost of asthma to society, including direct costs and productivity losses due to morbidity and mortality, as \$6.2 billion in 1990 (1990 dollars). This study used an analytic method sometimes referred to as the bottom-up method.<sup>29</sup>

Although the bottom-up method for estimating direct costs is straightforward, this method likely underestimates direct costs when only primary diagnostic events are summed. On the other hand, if secondary or further diagnostic codes are included in addition to primary diagnosis, the estimation might result in double counting of the costs of diseases.<sup>30</sup> Regression-based methods have emerged as a standard for estimating the incremental costs attributable to a disease or risk factor.<sup>17,18,21,22,31-36</sup>

In the most recent study on the direct costs of asthma, Kamble and Bharmal<sup>34</sup> used generalized linear regression models to estimate the incremental direct costs of asthma for adults and children separately using data from the 2004 Medical Expenditure Panel Survey (MEPS). The study finds that the 2004 incremental direct costs of asthma per person were \$2,077.50 for adults and \$1,004.60 for children, amounting to an estimated \$37.17 billion (2007 dollars) in total direct annual medical expenditures associated with asthma.

The purpose of this study is to provide a current estimate of the incremental direct medical costs and productivity losses due to morbidity and mortality from asthma at both the individual and national levels for the years 2002-2007. This study contributes to the literature on asthma because it is, to our knowledge, the first study in more than a decade to estimate total costs (incremental direct costs and productivity losses) due to asthma for persons of all ages. Furthermore, we use nationally representative person-level data, which are the most comprehensive single source of medical expenditures. We use regression-based techniques that take into account the distribution of medical costs and productivity days lost to estimate the incremental direct costs of asthma and

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Supported by the Air Pollution and Respiratory Health Branch, Centers for Disease Control and Prevention and supported in part by an appointment to the Research Participation Program at the Centers for Disease Control and Prevention, administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the US Department of Energy and the Centers for Disease Control and Prevention.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Disclosure of potential conflict of interest: S. B. L. Barnett has received research support from the OakRidge Institute for Science and Education. T. A. Nurmagambetov has declared no conflict of interest.

Received for publication November 10, 2009; revised October 16, 2010; accepted for publication October 20, 2010.

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0091-6749/\$36.00

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doi:10.1016/j.jaci.2010.10.020

productivity days lost because of asthma for the years 2002-2007. We estimate the value of mortality by using vital statistics reports and published estimates of the value of productivity losses.

## METHODS

### Data

Data for calendar years 2002-2007 came from the MEPS, a large-scale nationally representative set of surveys of families and individuals and their medical providers and employers. The surveys collect detailed data on health care use, expenditures, sources of payment, and health insurance coverage. The MEPS has been conducted annually since 1996; it is cosponsored by the Agency for Healthcare Research and Quality and the National Center for Health Statistics. The survey uses a complex design and provides population weights to create nationally representative estimates of the US noninstitutionalized population.<sup>37</sup>

The publicly available Household Component of the survey, used in the current study, uses an overlapping panel design in which participants are interviewed in person for 5 rounds over 2 full calendar years. Households and individuals provide information on their demographic and socioeconomic characteristics, employment, days disrupted by injury or illness, health care and medication use, medical conditions, and health status. The Medical Provider Component of the survey samples participants' medical providers and pharmacies and is used primarily as an imputation source to supplement household-reported expenditure information.<sup>37</sup> The full sample during the years 2002-2007 ranged from 30,964 to 39,163, and the response rate ranged from 56.9% to 65.9%.<sup>37-42</sup>

### Sample and identification of persons with asthma

For each year, data from the Household Component of the survey, including the medical conditions file and event files (office-based medical provider visits, hospital outpatient visits and special clinic visits, emergency department visits, hospital inpatient stays, and prescribed medicines), were merged with the full-year consolidated file by using the unique identification variables, thus creating a merged file of person-level data for each of the years 2002-2007. The data files from the 6 years were also pooled to produce estimates with greater reliability, with a total sample size of 206,851 persons. The complex survey design of MEPS was accounted for by use of person-level weights and survey commands within Stata 11 software<sup>43</sup> for all analyses and descriptive statistics, as recommended by the Agency for Healthcare Research and Quality.<sup>44</sup> All expenditures and wages were adjusted to 2009 dollars by use of the Medical Care Consumer Price Index and the Consumer Price Index.<sup>45</sup>

Individuals were identified as persons with asthma if an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code of 493 was associated with an office-based medical provider visit, a hospital outpatient visit, an emergency department visit, a hospital inpatient stay, or a prescription medication. Self-reported medical events and prescription medications that were said to be related to asthma were recorded as verbatim text and then converted by professional coders to an ICD-9-CM code of 493 within the data.<sup>46</sup> This case definition is similar to one version of the modified Council of State and Territorial Epidemiologists definition for probable asthma that performs well in identifying subjects with asthma in claims data.<sup>47</sup> The definition for asthma used by this study is utilization based, and hence it does not include persons who reported having asthma as a condition but did not have any asthma-related events or prescription medications during the calendar year. Persons with asthma consisted of 4.2% of the pooled sample, representing 11.6 to 13.2 million persons during the years 2002-2007. Although not directly comparable, this percentage is close to the average annual prevalence percentage of self-reported asthma episodes, which ranged from 3.9% to 4.3% during the years 2002-2007.<sup>48</sup>

### Dependent variables

The exclusive major categories of expenditures, which were dependent variables for the analyses of direct cost, are office-based medical provider

expenditures, hospital outpatient expenditures, emergency department expenditures, hospital inpatient expenditures, and prescribed medicine expenditures. The sum of these 5 major components of expenditures for the year, called total expenditures, was a dependent variable created for additional analyses of direct costs. The MEPS definition of expenditures is the sum of direct payments for care during the year, including out-of-pocket payments and payments by private insurance, Medicaid, Medicare, and other sources. Expenditures were chosen as the measurements of cost instead of charges because charges are often discounted and include uncollected liability, bad debt, and charitable care.<sup>37</sup>

The number of school days lost and the number of work days lost per calendar year\* were the dependent variables in estimating productivity losses attributable to asthma. During each survey round, respondents reported the number of days during which they missed a half day or more of work or school because of illness, injury, or mental or emotional problems.<sup>37</sup> Because partial and full days lost were indistinguishable in the data, all days lost were treated as full days in this study, which is consistent with previous studies using MEPS.<sup>22,24</sup> The incremental school days lost because of asthma were estimated for students aged 3 to 19 years, and the incremental work days lost because of asthma were estimated for persons who had worked during at least 1 survey round in a year.

### Independent variables

The independent variable of interest is asthma, a binary variable, with 1 indicating that the person had an asthma-related medical visit or prescription medication during the calendar year and 0 indicating otherwise. Independent binary variables included in the analyses were for age groups, marital status, minority races, educational levels, sex, income less than 200% of the poverty line, uninsured status (not having private or public insurance), and calendar year (only for the pooled sample). Estimates of the incremental effect of asthma might be biased if asthma is correlated with other conditions, and therefore comorbidities were adjusted for by including the D'Hoore adaptation<sup>49</sup> of the Charlson comorbidity index<sup>50</sup> as a continuous independent variable. The D'Hoore version allows for the index's use with ICD-9-CM codes, and it includes 17 conditions†; it has had good predictive power in an evaluation of published comorbidity indices for administrative databases.<sup>51</sup>

### Modeling the incremental direct costs of asthma

To select an appropriate econometric model, we followed the criteria outlined by Manning and Mullahy<sup>52</sup> and Buntin and Zaslavsky.<sup>53</sup> On the basis of their criteria, generalized linear models (GLMs) with log-link functions, which are differentially weighted nonlinear least-squares estimators, were selected; they are efficient with the correct choice of a variance function. To choose a specification among GLMs, we used the modified Park test<sup>52</sup> for each of the expenditure models on both the full and positive portion of the distribution of the dependent variables. The results of the modified Park tests indicated that a gamma distribution with a log link was the best-fitting GLM model for estimating incremental expenditures.

Although the choice of the GLM addressed the positive skewedness of the dependent variables, many of the dependent variables had a high

\*Some of the disability days reported by participants in panels 6 and 7 of the survey pertain to both 2002 and 2003. Therefore we multiplied the number of days lost by the percentage of days in each person's reference period pertaining to the year 2002. From 2003 onward, the disability days variables reflect only the data pertinent to the calendar year.

†The conditions include myocardial infarct, congestive heart failure, peripheral vascular disease, dementia, cerebrovascular disease, chronic pulmonary disease, connective tissue disease, ulcer disease, mild liver disease, hemiplegia, moderate-to-severe renal disease, diabetes, any tumor, leukemia, lymphoma, moderate or severe liver disease, and metastatic solid tumor. Although usually included in the index, ICD-9-CM codes related to asthma were not included in the computation of the index for this study because the condition is accounted for with a separate binary variable.

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