The Economic Burden of Asthma in the United States, 2008 - 2013

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ABSTRACT

Rationale: Asthma is a chronic disease that affects quality of life, productivity at work and school, healthcare use, and can result in death. Measuring the current economic burden of asthma provides important information on the impact of asthma on society. This information can be used to make informed decisions about allocation of limited public health resources.

Objectives: In this paper, we provide a comprehensive approach to estimate current prevalence, medical costs, cost of absenteeism (missed work and schooldays) and mortality attributable to asthma from a national perspective. In addition, we estimate the association of incremental medical cost of asthma with several important factors, including race/ethnicity, education, poverty, and insurance status.

Methods: The primary source of data was the 2008-2013 household component of the Medical Expenditure Panel Survey. We defined *treated asthma* as the presence of at least one medical or pharmaceutical encounter or claim associated with asthma. For the main analysis, we applied two-part regression models to estimate asthma-related annual per-person incremental medical costs and negative binomial models to estimate absenteeism associated with asthma.

Results: Out of 213,994 people in the pooled sample, 10,237 persons had *treated asthma* (prevalence = 4.8%). The annual per-capita incremental medical cost of asthma was $3,266 (in 2015 US dollars): $1,830 was attributable to prescription medication, $640 to office visits, $529 to hospitalizations, $176 to hospital-based outpatient visits, and $105 to emergency room visits. For certain groups, the per-person incremental medical cost of asthma differed from that of the population average, namely, $2,145 for uninsured persons and $3.581 for those living below the poverty line.

During 2008-2013, asthma was responsible for $3 billion in losses from missed work and school days, $29 billion from asthma-related mortality, and $50.3 billion in medical costs. All combined, the total cost of asthma in the U.S. based on the pooled sample amounted to $81.9 billion in 2013.

Conclusion: Asthma places a significant economic burden on the United States with a total cost of asthma, including costs incurred by absenteeism and mortality, of $81.9 billion in 2013.

INTRODUCTION

Asthma is a chronic disease of the airways, characterized by periods of reversible airflow obstruction resulting in symptoms of cough, wheeze, chest tightness, and dyspnea. In 2013, approximately 22.6 million people in the United States (7.3% of the population) had current asthma, including 6.1 million children aged < 18 years and 16.5 million adults (1). Asthma negatively affects quality of life, productivity at work and school, healthcare utilization, and can even result in death.

Asthma places a significant economic burden on the United States (2-6). The cost of asthma is a measure of the economic burden of the disease and represents the additional costs imposed by having asthma. Cost studies can influence public health policy decisions and help decision makers understand the scale, seriousness, and implications of the disease, so that resources can be identified to improve asthma management and reduce the burden of asthma (7,8). Cost of asthma reports present disease burden in monetary terms and allow reasonable comparison of the population effects of different chronic conditions (9-11).

Multiple studies on the cost of asthma in the United States (4-6, 12-16) have demonstrated that costs are affected by numerous factors, including new treatment options, federal and state policies, changes in price and healthcare market, and increasing effectiveness of asthma control programs (1). Dissemination of the medical and economic burden of asthma can inform decisions about allocation of public health resources.

The first comprehensive study of asthma economic burden estimated the cost to society at $6.2 billion (1990 US dollars) in 1990, including direct medical costs and productivity losses from morbidity and mortality (16). The authors used a gross-costing method, which was based on healthcare use and average per-unit cost data (17-22). The cost of asthma-related hospitalizations, for example, was estimated by multiplying the number of asthma hospitalizations by the average cost for one hospitalization (7,23).

Lately, in cost-of-illness studies it is increasingly common to use regression models to isolate the effect of diseases on healthcare costs (24,25). In 2009, Kamble and colleagues used generalized linear regression models (GLM) to estimate the cost of asthma using data from the 2004 Medical Expenditure Panel Survey (MEPS) (26). The authors found that the per-person incremental medical costs of asthma (additional cost associated with having asthma) were $2,078 for adults and $1,005 for children, amounting to an estimated $37.2 billion (2007 US dollars) in total medical cost associated with asthma. Using 2003 and 2005 MEPS data, Sullivan and colleagues found that adults with asthma incurred $1,907 (2008 US dollars) annually in incremental medical costs (27). In 2011, Barnett and Nurmagambetov estimated per-person incremental medical cost of asthma at $3,856 (2009 US dollars) and the total national cost of asthma at $56 billion (4).

The objective of this study was to provide current estimates of medical, absenteeism, and mortality costs of *treated asthma* at both individual and national levels for the years 2008–2013. For the purposes of this paper, we define *treated asthma* as having had at least one medical or pharmaceutical encounter or claim associated with asthma. Our estimates also include the prevalence of *treated asthma*, per-person cost, and total cost of *treated asthma* in the U.S. In addition, we examined the effects of several demographic and socioeconomic factors on asthma medical costs including income, education, age, race/ethnicity, and insurance status.

METHODS

Medical Expenditure Panel Survey

We used data from MEPS for calendar years 2008–2013 (28). The survey sample of households for each year was drawn from respondents in the previous year's National Health Interview Survey, a national representative sample of the U.S. civilian noninstitutionalized population (29). MEPS collects detailed information on healthcare use, expenditures, payment source, and health insurance coverage. Co-sponsored by the Agency for Healthcare Research and Quality (AHRQ) and the National Center for Health Statistics (NCHS), MEPS uses a complex survey design and provides population weights to create nationally representative estimates for the U.S. population.

The MEPS household component contains detailed self-reported information on demographics, socioeconomic status, health conditions, insurance status, healthcare use and expenditures, employment, missed work, and missed school. MEPS data cover expenditures for office-based provider visits, hospital-based outpatient visits, inpatient hospitalizations, emergency room (ER) visits, prescription medications, home health care, dental services, and vision aids. The MEPS medical provider component is a follow-up survey covering a sample of pharmacies and healthcare providers. The full 2008-2013 MEPS sample ranged from 32,846 to 38,974 persons annually, and the response rate ranged from 53.5% to 59.3%.

Study Samples

We merged data from the MEPS household component full-year consolidated data files with household component events files. Event files included data on office-based physician visits, hospital-based outpatient and special clinic visits, ER visits, hospital inpatient stays, and prescription medications. To eliminate missing information and to improve accuracy, MEPS collects additional information from a sample of medical providers and applies a specific imputation procedure for any remaining missing values (28). Using unique identification variables, we created a merged file of person-level data for each of the years during 2008–2013. Pooled data files from these 6 years provided a total sample size of 213,994 persons. To address the complex survey design of MEPS, we used person-level weights and survey commands within Stata®12 software for the analysis (30). For the remainder of this paper, all monetary values were adjusted to 2015 US dollars using the Consumer Price Index and Medical Care Consumer Price Index (31). We applied the Stata *twopm* program to run two-part regression models (TPRM) (32).

Case Definition of Asthma

In our analysis we used the following definitions: ***treated asthma:*** International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code 493 (asthma) associated with an office-based medical provider office visit, hospital-based outpatient visit, ER visit, hospital inpatient stay, or filled prescription medication for asthma; ***lifetime asthma***: affirmative response to the question: “Has a doctor or other health professional ever told you that you had asthma?” ***Current asthma:*** having *lifetime asthma* plus an affirmative response to “Do you still have asthma?” By these definitions, a person with *treated asthma* also has *current asthma*, and a person with *current asthma* also has *lifetime asthma*. For the remainder of this paper, *asthma* refers to *treated asthma*, unless otherwise specified. Given that we use expenditure data to measure medical cost, *treated asthma* is the term most relevant to the discussion.

Dependent Variables

For our analysis, we used annual per-person total healthcare expenditure (or medical cost), and separate annual per-person expenditures for office visits, hospital outpatient visits, ER room visits, hospital admissions, and prescription medications. MEPS defines per-person expenditure as the sum of all direct payments by all payers for care during the year, including out-of-pocket payments, payments by all public and private insurances, and other sources. Given the high proportion of zero values found in annual per-person expenditure data, reflecting the frequency of persons having no healthcare expenditures during the year, we used a binary dependent variable that identified persons with positive healthcare expenditure. We also used two additional dependent variables, missed work and school days, to estimate the effect of asthma on absenteeism.

Independent Variables

The main independent variable for the analysis was a binary variable in which 1 indicated that a person had asthma and 0 if not. Sex, age, age squared, race/ethnicity, education, marital status, income level, health insurance, U.S. Census regions, and the D'Hoore adaptation of the Charlson comorbidity index were also included (33). Enrollment in a health care insurance plan meant continuous enrollment throughout the year; uninsured meant uninsured for the entire year.

Incremental Medical Cost of Asthma

To estimate the incremental medical costs of asthma and related absenteeism during 2008-2013, we applied regression-based techniques that take into account distribution of medical costs and missed work and school days.

We used a TPRM to estimate per-person annual incremental medical cost of asthma. The model produces the incremental cost of asthma, or the difference between predicted annual medical expenditure of the person with asthma (the value of the variable for asthma equal to 1) and the predicted annual medical expenditure of the same person, assuming that person does not have asthma (changing the value from 1 to 0). Using a TPRM allows us to isolate the effect of asthma on medical cost while controlling for the presence of other factors.

The first part of the TPRM used logistic regression to predict the probability of any positive healthcare expenditure. The second part estimated actual expenditure conditional on having a non-zero expenditure during the year. Both parts used the same set of independent variables. To select the appropriate model for the second part of the TPRM, we used criteria recommended by Manning and Mullahy (25). Based on their algorithm, in the second stage we used a GLM with a gamma distribution and a log link to estimate per-person annual medical expenditures for all persons who had a non-zero expenditure. The TPRM generates a prediction function for per-person total medical cost; then the *Stata*®12 *marginal effect* command applied to the *asthma* variable estimates incremental medical cost of asthma. Incremental cost of prescription medications, office-based visits, hospital-based visits, ER visits, and hospitalizations were similarly obtained.

Absenteeism Cost

For analysis of missed work and school days, we used a negative binomial model with the same independent variables used to calculate incremental medical cost. We produced two predicted values for missed days: one for persons with asthma and one for the same persons without asthma by simulating the removal of asthma. The difference between these two predicted values was the expected incremental work or school days lost due to asthma.

To estimate the cost of missed work or school days, we used a *human capital* approach, where the cost of one missed work day was equivalent to a lost daily wage (36). Daily wage was estimated using actual or imputed number of hours worked per week and hourly wage. To assign the value to the missed school day, we assumed that one parent missed work to care for the child, so the value was equivalent to the day's lost wage. For a two-parent household, we assumed the lower earning or non-working parent would stay home and, for the latter, the value of the missed day was based on the national minimum wage.

Mortality Cost

For mortality data, we used CDC's Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) web application, extracting cases with asthma as underlying cause of death for years 2008–2013 (37). To assess the value of mortality we used the value of statistical life (VSL) approach (34).

RESULTS

Out of 213,994 people in the pooled sample, 10,237 persons or 4.8% had asthma (Table 1). During 2008-2013, the annual sample size ranged from 32,846 in 2010 to 38,974 in 2012, with prevalence ranging from 4.6% in 2012 to 4.9% in 2013. The average age in both groups was the same; however, the population with asthma had a larger proportion of children aged 5–14 years.

Women and blacks were more likely to have asthma. Married adults were less likely to have asthma. Among people with asthma, a larger proportion lived in poverty (< 100% of poverty line) or near the poverty line (from 100% to 125% of poverty line). Persons with asthma had a significantly higher Charlson comorbidity index than did persons without asthma.

The proportion of persons covered by Medicaid was significantly higher (33%) in the asthma group than in the non-asthma group (17%). A smaller proportion of the asthma group (6%) was uninsured, compared with the non-asthma group (18%). Persons with asthma were also generally less educated and had lower incomes than their non-asthma counterparts.

On average, the total unadjusted medical cost of people with asthma was more than twice that of people without asthma; this was also true for the remaining five categories of healthcare expenditure. On average, children and adults with asthma also missed significantly more days of school and work than those without asthma.

We included more details on the methods and results for the annual estimates, variances, and confidence intervals in the online data supplement.

Incremental Cost of Asthma

Table 2 shows the results of the TPRM for six major medical expenditure categories for each year during 2008–2013 and for the pooled sample. The total annual per-person incremental medical cost of asthma for the pooled sample was $3,266; expenditure for prescription medications was $1,830; office-based visits, $640; hospital-based outpatient visits, $176; ER visits, $105; and inpatient hospital admissions, $529. All point estimates were significant at the 95% confidence level. The results from the TPRM and the marginal effect analysis can also be applied to specific subpopulations of interest identified by the independent variables. For example, those living below the poverty line incur significantly higher incremental medical cost of asthma than those with higher income (Figure 1). Compared to $3,266 for the entire population, the average medical cost for women was $3,322; children (age < 18), $1,737; blacks, $3,145; Hispanics, $2,905; high school graduates, $3,424; Medicaid population, $3,453; and the uninsured, $2,145 (Table 3).

Prevalence of Asthma and Total Medical Cost of Asthma

During 2008-2013, the annual asthma prevalence was almost 5.0% with the annual total medical cost nearly $50.3 billion based on the pooled sample. Prevalence of asthma in the United States ranged from 4.8% in 2008 and 2009 to 5.2% in 2011 and the total medical costs ranged from $39.3 billion in 2008 to $67.5 billion in 2012 (Table 4).

Absenteeism and Mortality Cost Attributable to Asthma

Table 5 shows results of the negative binomial regression model for incremental days lost due to asthma based on the pooled sample. Asthma was responsible for additional 1.8 missed workdays and 2.3 missed school days per-person per year. Nationally, over 8.7 million workdays and over 5.2 million school days were lost due to asthma, amounting to a total loss of $3 billion. During 2008–2013, asthma caused on average 3,168 deaths, costing $29.0 billion per year (Table 6).

Total Cost of Asthma

To estimate the total economic impact of asthma on society, we combined medical, absenteeism, and mortality costs (Table 7). The total cost of asthma for the pooled sample was $81.9 billion.

DISCUSSION

Our analysis underscores the serious and substantial economic burden of asthma on society. Based on the 2008-2013 pooled sample, annual per-person medical costs attributable to asthma were $3,266, while annual per-person expenditures for prescription medications exceeded the amount spent by persons without asthma by more than $1,800, amounting to 56% of total medical expenditures (Table 2). Recent studies support this finding (4,27,38,39). The proportion of the combined expenditure for prescription medication and office-based visits exceeded 75%, compared with 19.4% for asthma-related (ER) visits and hospital admissions, which is also consistent with recent studies (4,38).

Children with asthma missed 2.3 additional school days annually during 2008–2013, at a per-child cost of $207, notwithstanding loss of quality of life. This is consistent with other studies (4,38,40,41). For adults, on average, asthma caused 1.8 days of missed work, resulting in almost $214 lost earnings per worker annually, which is consistent with previous studies (4,27,40). Our estimates of missed work and school days were also comparable with findings by both Wang and colleagues and Sullivan and colleagues, respectively (27,41). Our mortality costs of asthma using the VSL method were higher than those reported in Barnett and Nurmagambetov, who used a human capital approach (4,42).

During 2008-2013, the total cost of asthma based on the pooled sample was estimated at $81.9 billion, of which 61% was for medical costs; nearly 39% was attributable to absenteeism and mortality. These numbers are consistent with previous studies that have suggested that increased medical costs, influenced largely by cost of services and medications, are primarily responsible for increases in the total cost of asthma; alternatively, the value of missed work and school days is determined by wages, while mortality costs depend on the VSL (4,27).

Given our analysis was based on *treated asthma*, the study excluded possible contribution to the costs by people with *lifetime* or *current* asthma who did not use any healthcare service in a given year (1). For example in 2013, from about 22.6 million people with *current asthma,* only 15.5 million had *treated* asthma, which means that about one in three persons with *current asthma* had no asthma-related encounter with a medical provider or a pharmacy in that year. Acknowledging data limitations for accurate estimation, we also did not include nonmedical costs, such as transportation, appointment wait time, presenteeism (not fully functioning at work because of illness), or intangible costs of pain and suffering. Consequently, our findings might actually underestimate the total cost of asthma.

Our results are comparable to those reported in 2013 by Jang and colleagues, who estimated trends in asthma costs from 2000 through 2009 using MEPS data (38). The authors used *lifetime asthma* (vs. *treated asthma)*, which may account for the higher cost of asthma: $47.2 billion vs. our $39.3 billion in 2008 and $69.4 billion vs. $53.9 billion in 2009. Their prescription medication costs accounted for 44% vs. 51% in our analysis. In a recent publication on healthcare expenditure in the U.S., Bui and colleagues reported that in children with asthma, prescription costs account for over 47% of all medical costs associated with asthma, which is comparable to our 51% estimate (39).

Rappaport and colleagues used 2007 MEPS data to estimate direct and indirect cost of current asthma using a combination of propensity score matching and GLM (43). Their estimated $65.5 billion total cost of asthma in the U.S. is comparable to our estimates. Sullivan and colleagues studied adults ≥ 18 years based on 2003 and 2005 (27). Their estimated $2,099 for 2005 of per-person medical expenditure for asthma is lower than our estimated $2,698 for 2008. Using *treated asthma* and the Heckman model, which differs conceptually and statistically from TPRM (32), they estimated that adults with asthma had 1.2 more missed workdays than adults without asthma; this is consistent with our results of 1.8, CI = (1.2 – 2.4), on work absenteeism (Table 5).

In a series of articles (51, 52, 53) Sullivan and colleagues addressed healthcare use, absenteeism, mortality, and associated costs for school-aged children with asthma based on 2007-2013 MEPS data. They found that the total medical cost of asthma for school-aged children was almost $6 billion (in 2015 dollars). Using a human capital approach, they estimated the cost of 130 deaths at $211 million (in 2015 dollars). According to the authors, school-aged children with poor asthma control incurred $3,063 higher cost than children without asthma.

Our results show that persons with no health insurance had significantly lower incremental medical cost of asthma compared to the population average of $3,266, suggesting that these individuals may have either paid for their asthma care out-of-pocket and/or limited their care-seeking compared to the population average.

Asthma also disproportionately affects people living in urban areas (44,45). Previous studies showed that indoor and outdoor environmental pollution are major factors contributing to higher risk for asthma attacks and higher cost of asthma. People with lower incomes often live in places with higher concentrations of environmental asthma triggers (46-49). The results from this study suggest that poor people (with incomes < 100% of poverty threshold) have significantly higher medical costs because of asthma than those with higher incomes. On the other hand, having other levels of income (near poor, low, middle, high) does not seem to affect medical costs (Figure 1). People with very low income are also more likely to qualify for Medicaid which essentially pays for high asthma treatment costs. Environmental interventions to reduce indoor asthma triggers for low-income families have been found to be cost-effective and are encouraged to reduce the burden of asthma (47,49,50).

Our results also show that Blacks and Hispanics have lower medical costs for asthma relative to the population average (Table 3). Multiple studies demonstrated that these groups have consistently higher rates of hospitalizations and ER visits associated with asthma (54,55,56) but lower rates of asthma prescription medication and outpatient visits. This may explain their lower total medical cost of asthma, since prescription medications and outpatient visits are the two largest contributors to total medical care costs (Table 2). Not having health insurance or high out-of-pocket costs for insured persons may preclude purchasing asthma medications, particularly long-acting anti-inflammatory asthma drugs, or seeking regular outpatient care. Further, language and health literacy barriers may also limit effectiveness of asthma self-management education (57,58). Medicaid or other health insurance coverage with lower out-of-pocket payments may improve access to routine care and prescription medications for persons with asthma in these groups.

Conclusion

This study suggests that the cost of prescription medications and office-based visits comprise the bulk of the medical costs of asthma. The combined costs of medical care, mortality and absenteeism render the total cost of asthma a substantial and serious economic burden on society. These findings highlight the critical need to support and further strengthen asthma control strategies through increased provision of guidelines-based care, improvements in self-management, and reduction of environmental asthma triggers in order to reduce ER visits, hospitalizations, absenteeism, and mortality.

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