Incidence and Cost of CAP in a Large Working-Age Population

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Objectives: To estimate incidence rates and quantify excess medical and productivity cost of community-acquired pneumonia (CAP) in a commercially insured, working-age population.

Methods: Using the Thomson Reuters MarketScan Commercial Claims and Encounters Database, we estimated the annual incidence of CAP from 2003 through 2007 and evaluated its excess direct medical and productivity costs due to short-term disability and workplace absenteeism for adult patients aged 18 to 64 years. A cohort of CAP patients was 1:3 propensity score matched to a control cohort without pneumonia. Both excess direct medical costs and excess productivity costs were estimated in multivariate ordinary least squares (OLS) and generalized linear model (GLM) adjusting for demographic and clinical characteristics.

Results: A total of 402,831 patients with CAP and 1,208,231 matched controls were included. Overall annual CAP incidence was 4.89 cases per 1000 person-years. Excess annual medical cost of CAP ranged from $7220 by OLS to $11,443 by GLM. Inpatient costs, outpatient costs, and pharmacy costs explained 34%, 51%, and 15% of this excess cost of the GLM models, respectively. CAP patients had an additional productivity cost of $2391. Among adults younger than 65 years, these estimates imply an incidence of CAP of 950,000 annual cases at a cost of $10.6 billion (range: $9.04-$13.1), of which 80% are direct medical costs and 20% are productivity costs.

Conclusions: CAP is a frequent and costly event in a working-age population with a national cost of $10.6 billion. Interventions that could successfully prevent CAP could have a significant impact on healthcare costs and productivity.

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For author information and disclosures, see end of text.

Pneumonia ranks among the top causes of death and hospitalization and is a major driver of healthcare costs. Most cases are classified as community-acquired: pneumonia occurring in a patient who is not hospitalized or residing in a long-term facility. In the United States, 55,000 deaths were attributed to pneumonia in 2006, with 1.2 million hospital discharges.[1] While the burden of this disease is highest among the elderly, adults younger than 65 years accounted for 6000 deaths and 325,000 hospitalizations in 2006.[1]

Despite the obvious burden of this disease on the healthcare system, surprisingly few studies have attempted to estimate the cost burden. Available estimates come from the mid-1990s where the total cost burden of treating community-acquired pneumonia (CAP) was estimated at $12.2 billion,[2] $10 billion,[3] and $8.4 billion,[4] excluding productivity costs. Productivity costs were estimated for a Fortune 100 company where the annual total employer costs for pneumonia patients were $14,837, with nearly 30% attributed to work absence and disability (disability claims were assigned the cost of 5 workdays in addition to imputed illness absence days).[5] This current analysis addressees this limitation by evaluating the total cost burden of CAP among non-elderly adults including both direct medical costs and productivity costs in a large cohort of commercially insured employees and dependents, geographically dispersed throughout the United States.

METHODS AND MATERIALS

Data Source

This study used the Thomson Reuters MarketScan Commercial Claims (Commercial) and Encounters database to determine the incidence and medical costs of CAP. The Commercial database contains adjudicated medical and outpatient prescription drug claims of several million employees and their dependents (annually), covered under a variety of health plan structures. In 2008, there were over 34 million covered lives in the Commercial database. Productivity costs were assessed on a subset of patients with data available in the Thomson Reuters Health Productivity and Management (HPM) database. The HPM database contains employee-level workplace absenteeism and short-term disability data for a subset of approximately 1.4 million patients in the Commercial database.

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The Commercial and HPM databases have been de-identified and are in compliance with the Health Insurance Portability and Accountability Act (HIPAA) regulations; this analysis was exempt from Institutional Review Board approval.

Take-Away Points

This study estimated the burden and incidence of community-acquired pneumonia (CAP) among non-elderly adults (younger than 65 years) in the United States and determined the following:

- CAP is common among non-elderly adults (4.89 cases per 1000 person-years). There are approximately 950,000 cases of CAP among non-elderly adults annually.
- CAP costs approximately $10.6 billion annually.
- CAP has high excess medical costs, both per case (range: $7220-$11,443) and projected nationally ($6.8-$10.8 billion).
- Approximately 20% of the burden of CAP comes from indirect costs. Preventing CAP could have a substantial impact on healthcare costs and productivity.

Patient Selection

We selected adults aged 18 to 64 years in the Commercial database between July 1, 2002, and December 31, 2007. We identified all claims for pneumonia based on the *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes (codes: 480.xx-486.xx). The index date for any patient with pneumonia was the date of the first diagnosis of pneumonia following 6 months of continuous medical and prescription coverage. This means that while pre-index periods could go back into 2002, index dates had to occur between January 1, 2003, and December 31, 2007. Patients with a diagnosis of pneumonia in the 6-month pre-index period were excluded. There was no minimum requirement for post-index continuous medical and prescription coverage; patients were followed up to 12 months, depending on data availability.

Pneumonia was categorized as community-acquired if the patient had either a principal or non-principal diagnosis of pneumonia on an outpatient claim or a principal diagnosis of pneumonia on an inpatient claim with no evidence of an inpatient or long-term care stay in the previous 30 days. (For inpatient admissions, principal diagnosis is the condition established after study to be chiefly responsible for occasioning the admission of the patient to the hospital or for care, which may or may not be the admitting diagnosis for the inpatient admission. In the case of outpatient services, principal [or primary] diagnosis is the main condition treated or investigated during the relevant episode of outpatient [ambulatory] healthcare.) The remaining patients with a diagnosis of pneumonia were assumed to have healthcare-associated pneumonia or hospital-acquired pneumonia (HAP) and were excluded from this analysis. Patients in the database without a diagnosis of pneumonia were included in incidence calculations and as controls in cost analyses. Control patients were randomly assigned an index date between January 1, 2003, and December 31, 2007, and were also required to have 6 months of continuous medical and prescription coverage preceding the index date.

This study employed the most recent HPM data available, which covered January 1, 2003, through December 31, 2006. Patients could contribute work absence, short-term disability, or both forms of data; work absence and short-term disability data were analyzed separately to maximize the sample sizes. While the direct costs analysis includes data on both employees and dependents, indirect cost data is only available for employees.

Outcome Variables

Healthcare expenditures were derived from all inpatient medical, outpatient medical, and outpatient pharmacy claims data captured in the Commercial database during the study period. (Emergency department [ED] visits that did not lead to an inpatient stay were classified as outpatient medical visits. ED visits were classifed as inpatient medical if they led to an inpatient stay.) Medical expenditures were defined as total gross payments to a provider, including deductibles, copayments, and coordination of benefits. Pharmaceutical expenditures were the actual reimbursement to the pharmacy, including the drug's administrative dispensing fee, ingredient cost, patient portion of costs, and sales tax. Expenditures for services provided under capitation arrangements were estimated using payment proxy based on procedure code and region of care by the data provider. All expenditures were inflated to 2008 dollars by multiplying each year's cost by the US Bureau of Labor Statistics Medical Care Specific Consumer Price Index.[6]

Productivity costs were quantified using the number of employer-recorded days of absence from work and short-term disability days during the post-index period. A wage constant of $41 per hour was used in this analysis. This was based on a previous benchmarking study of health- and productivity-related costs for 32 companies across the United States and adjusted to 2008 US dollars.[7,8] It was assumed a patient would only receive 70% of wages while on disability, thus a $28.70/hr wage constant was used to valuate short-term disability claims.

Patient Characteristics

Patient demographic characteristics were measured on the index date and included age, gender, US Bureau of Census region of residence, health plan type, insurance plan capitation, population density status (urban vs rural), industry type, em-

ployee classification (hourly versus salary), and union classification (union vs non-union). Clinical variables calculated during the baseline period included the Deyo Charlson Comorbidity Index (CCI); comorbidities of chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), cancer, cardiovascular disease (CVD), other musculoskeletal surgery, diabetes, and asthma; pre-period use of antibiotics, long-acting beta-agonists, short-acting beta-agonists, and systemic corticosteroids; indicator of whether there was a hospitalization in the 1 month prior to index date; 6-month pre-period costs for inpatient, outpatient, and pharmacy; and time observed for follow-up.

Analysis

Incidence of CAP

The incidence of CAP for the 5-year study period was calculated based on all the eligible beneficiaries in the Commercial Database between January 1, 2003, and December 31, 2007, that had at least 6 months of uninterrupted enrollment preceding the index date for pneumonia or controls. The numerator was the number of cases during the study period. The denominator was the total enrollment time during the study period in the Commercial Database among potentially eligible patients. Incidence rates were reported as CAP cases per 1000 person-years and stratified by gender and age categories.

Excess Cost of CAP

In order to estimate the direct medical cost and productivity burden of pneumonia, we generated a control group from all beneficiaries without a pneumonia diagnosis using nearest neighbor propensity score matching without replacement in a 3:1 control:case matching ratio. The propensity score was estimated by using a logistic regression modeling the presence of pneumonia as the dependent variable with the following covariates: index year; quarter; age; gender; geographic region; plan capitation status; industry; length of follow-up; baseline Deyo CCI; and baseline comorbid conditions, including asthma, cancer, CVD, CHF, COPD, diabetes, and HIV. Propensity score matching was performed and reported separately among the subset of patients (and controls) with work absence and short-term disability data.

Despite the propensity score match, imbalances in risk will remain, and with the highly skewed distribution of costs, these imbalances may have an important influence on the estimate of excess costs. Therefore, in addition to the excess costs estimated from the observed differences between the pneumonia and non-pneumonia matched groups, we estimated excess costs in multivariate analyses by ordinary least squares (OLS) and generalized linear model (GLM). Separate models were run for total inpatient cost, ambulatory care excluding pharmacy cost, and pharmacy cost due to the distinct cost distribution for each of these categories. These predicted costs were then summed in order to assess total costs. Similarly, we used separate models to analyze absenteeism and short-term disability. Two-part models were used for inpatient costs, absenteeism, and short-term disability.

For GLM, the log link and gamma variance functions were used. The control variables for all multivariate models included: age; gender; insurance type; region; urbanicity; employee class (union vs non-union); employment status; employee relationship; Deyo CCI score in pre-period; COPD; CHF; cancer; CVD; other musculoskeletal surgery; diabetes; asthma; pre-period use of antibiotics, long-acting beta-agonists, short-acting beta-agonists, systemic steroids; indicator of whether there was a hospitalization in the 1 month prior to index date; total inpatient costs in pre-period; total outpatient costs in pre-period; total pharmacy costs in pre-period; and time observed for follow-up. All cost estimates are in 2008 US dollars.

National Projections of CAP

To quantify the total annual cost of CAP that occurs in the US population aged 18 to 64 years, we multiplied our estimate of cost of an episode of CAP by our estimate of the incidence of CAP and by the number of people in the United States in this age group. We quantify total annual costs of CAP with and without productivity costs. We express our range of methodological uncertainly by producing estimates for each of our 3 methods of estimating medical and productivity costs. We quantify uncertainty to stochastic variation in our estimates through Monte Carlo simulation based on the means and standard errors of inputs with distributional assumptions. Because each input could be skewed to the right and had to be non-negative, we fitted lognormal distributions to each major input and ran a simulation with 20,000 iterations. The simulation was done in Crystal Ball, Fusion Edition, version 11.1, and Excel 2007 software packages.[9,10]

RESULTS

Incidence

Table 1 contains a summary of the incidence of CAP among patients in the MarketScan Commercial Database, in total and stratified by age. Annualized overall incidence for this population was 4.89 cases per 1000 person-years. This incidence calculation was based on the 402,831 cases of CAP identified from 2003 to 2007 in our sample of 36.25 million commercially insured adults aged 18 to 64 years, with a total enrollment time of about 83 million years of risk. We project this annualized rate to the current US adult non-elderly

Table 1. Annual Incidence of CAP by Age Group in Commercially Insured Population Aged 18 to 64 Years From 2003 Through 2007; 2010 National Projections

		Study Population		Incidence of CAP per 1000 Person-Years			2010 National Projections			
								Projected CAP Cases		
Attribute	CAP Cases	Population at Risk	Total Person-Years at Risk	Point Estimate	Lower 95% CI	Upper 95% CI	US Population[a]	Point Estimate	Lower 95% CI	Upper 95% CI
Sex										
Male	183,802	17,256,074	39,160,787	4.72	4.697	4.740	96,928,042	457,370	455,279	459,461
Female	219,029	18,996,155	43,708,030	5.04	5.019	5.061	96,780,893	487,799	485,756	489,842
Age group (y)										
18-34	71,020	13,073,202	25,535,624	2.79	2.768	2.809	72,316,689	201,676	200,193	203,159
35-44	83,980	8,600,271	20,291,220	4.16	4.131	4.187	41,219,708	171,434	170,275	172,594
45-54	114,318	8,581,093	22,321,352	5.16	5.126	5.186	44,677,764	230,350	229,015	231,685
55-64	133,513	5,997,663	14,720,621	9.17	9.123	9.221	35,494,774	325,554	323,808	327,300
All	402,831	36,252,229	82,868,818	4.89	4.873	4.903	193,708,935	946,893	943,969	949,817

CAP indicates community-acquired pneumonia; CI, confidence interval.
[a] *Source:* US Census Bureau.
CAP was assumed to occur, on average, halfway through a CAP patient's enrollment.
As sex and age distribution in our study population do not exactly mirror those in the US population, extrapolations by sex, age group, and overall are not exactly equivalent.

population to arrive at an estimate of 947,000 cases of CAP in 2010 among adults aged 18 to 64 years. This analysis suggests increasing incidence with age; incidence among patients aged 55 to 64 years was 3.3 times the incidence of the group aged 18 to 34 years.

Demographics and Baseline Clinical Characteristics of CAP Sample

The demographic characteristics and pre-index period clinical characteristics of our 402,831 CAP cases are shown in Table 2. Mean age of CAP patients was 47 years and 45.6% were male. The most prevalent comorbid conditions were CVD (22.2%), diabetes (8.1%), asthma (6.3%), cancer (6%), and COPD (4.1%). CAP patients had an average CCI of 0.44. Mean length of follow-up was 318 days. The baseline summary statistics of the 1,203,823 matched controls without CAP are also displayed in Table 2. Demographic characteristics were similar between CAP patients and their controls, as the standardized differences were typically in the 1% to 3% range. The highest standardized differences among the characteristics included in the match were COPD (7.2%) and comprehensive insurance (7.3%). Pre-period outpatient costs were not included in the match and have standardized differences above 10. These characteristics, as well as all characteristics used in the match, were included in the multivariate analysis.

Direct Medical and Productivity Costs

Annualized total medical costs (including inpatient, outpatient, and outpatient pharmacy costs) were $14,038 (standard deviation [SD] = $38,537) for patients with CAP and $5096 (SD = $17,410) for patients without pneumonia. This represents $8942 of excess total medical costs of CAP. Inpatient costs are responsible for 47% of excess total medical costs, outpatient for 42%, and pharmacy for 11%. Adjusted excess total medical costs ranged from $7220 to $11,443 for the OLS and GLM models, respectively. Table 3 contains the full direct medical cost results.

Among patients with HPM eligibility, 23% of patients with CAP had a short-term disability claim compared with 10% of their matched controls (P <.001); total short-term disability hours per claim were similar for patients with CAP and their matched controls (381 hours versus 399 hours, P = .081). Patients with CAP also had higher total absenteeism hours (235 hours vs 214 hours, P <.001). As shown in Table 4, the productivity cost analysis showed that compared with controls, patients with CAP had $1304 in excess short-term disability costs and $889 in work absence costs. These results are relatively insensitive to multivariate adjustment via OLS or GLM. There is more stochastic variation in these estimates than in the medical cost estimates because the sample sizes for the productivity data are much smaller than for the medical data. Nevertheless, all excess cost estimates are statistically different from zero.

Table 5 summarizes a range of national cost estimates based on US population estimates for the US population aged 18 to 64 years of 194 million. We project direct medical costs to be $8.5 billion and productivity costs to be $2.1 billion for the US

Table 2. Baseline Characteristics of Patients Aged 18 to 64 Years With CAP and Non-pneumonia Matched Controls

	Pneumonia Patients	Non-pneumonia Matches	Standardized Difference (%)
Sample Size	402,831	1,203,823	Not Applicable
Sociodemographic characteristics of patients			
Male	45.6%	45.9%	0.58
Age in years, mean (SD)	46.8 (12.2)	46.5 (12.3)	2.37
Age group (y)			0.00
18-34	17.6%	17.6%	0.02
35-44	20.8%	20.9%	0.02
45-54	28.4%	28.8%	0.87
55-64	33.1%	32.7%	0.87
Comorbid conditions in patients			0.00
Charlson-Deyo index, mean (SD)	0.44 (1.07)	0.45 (1.02)	0.74
Comorbidities of interest			
Asthma	6.3%	6.0%	1.31
Cancer	6.0%	6.2%	0.98
Cardiovascular disease	22.2%	23.0%	1.93
Congestive heart failure	1.3%	1.1%	1.91
COPD	4.1%	2.7%	7.23
Diabetes	8.1%	8.6%	1.65
HIV/AIDS	0.3%	0.3%	0.39
Hepatitis B	0.0%	0.0%	0.12
Hepatitis C	0.4%	0.2%	2.30
Orthopedic surgery	0.1%	0.2%	1.27
Other musculoskeletal surgery	2.2%	2.3%	0.98
Pregnancy	0.8%	1.0%	1.40
Patient's follow-up in days, mean (SD)	318.2 (97.6)	318.4 (100.1)	0.20
Insurance plan type			
PPO	55.0%	56.3%	2.50
HMO	20.2%	19.9%	0.80
POS	10.4%	10.4%	0.16
Comprehensive	8.7%	6.8%	7.27
Other	5.6%	6.6%	4.07
Plan type			
Capitated	21.7%	21.7%	0.13
Geographic region			
Northeast	10.6%	10.7%	0.43
North Central	27.0%	26.6%	0.90
South	41.8%	42.4%	1.13
West	20.2%	19.9%	0.68
Unknown	0.5%	0.4%	0.30
Urban/rural residence			
Urban	80.6%	82.2%	4.33
Rural	19.0%	17.4%	4.29
Unknown	0.4%	0.4%	0.46
Industry type			
Manufacturing, durable goods	20.8%	20.7%	0.29
Transportation, communications, utilities	10.5%	10.6%	0.56
Services	6.3%	6.3%	0.23
Manufacturing, nondurable goods	5.4%	5.5%	0.54
Finance, insurance, real estate	5.3%	4.9%	1.88
Retail trade	4.5%	4.9%	2.05
Oil and gas extraction, mining	0.8%	0.8%	0.36
Unknown	46.4%	46.2%	0.45
Dependent status			
Employee	63.3%	62.3%	2.09
Dependent	36.7%	37.7%	2.09
Pre-period expenditures			
Total inpatient costs	$1005 ($10,752)	$1078 ($9746)	0.71
Total outpatient costs	$2927 ($12,033)	$1896 ($7291)	10.36
Total outpatient pharmacy costs	$1055 ($2318)	$686 ($1704)	18.14

AIDS indicates acquired immune deficiency syndrome; CAP, community-acquired pneumonia; COPD, chronic obstructive pulmonary disease; HIV, human immunodeficiency virus; HMO, health maintenance organization; POS, point of service; PPO, preferred provider organization; SD, standard deviation.

Table 3. Annualized Excess Direct Medical Cost of CAP by Cost Component and Method

	Pneumonia		No Pneumonia		Excess cost[a]
Method/ Type of cost	**Mean**	**SD**	**Mean**	**SD**	**Mean**
Observed, matched, unadjusted					
Inpatient cost	$5347	$27,394	$1142	$9928	$4204
Outpatient cost	$6532	$18,815	$2758	$10,915	$3774
Pharmacy cost	$2159	$4475	$1196	$3105	$964
Total medical cost	$14,038	$38,537	$5096	$17,410	$8942
Ordinary least squares regression					
Inpatient cost	$5091	$5170	$1316	$2146	$3776
Outpatient cost	$6425	$4427	$3461	$4427	$2964
Pharmacy cost	$2009	$1652	$1529	$1652	$480
Total medical cost	$13,525	$10,548	$6305	$7546	$7220
Generalized linear model					
Inpatient cost	$5399	$6035	$1476	$2547	$3923
Outpatient cost	$9267	$18,126	$3447	$6743	$5820
Pharmacy cost	$3036	$4416	$1335	$1942	$1701
Total medical cost	$17,702	$26,668	$6258	$10,520	$11,443

CAP indicates community-acquired pneumonia; SD, standard deviation.
Sample sizes for analysis of excess direct medical cost consisted of 405,643 pneumonia patients and 1,216,929 matched controls.
[a]All excess cost estimations are statistically significant at $P < .001$.

Table 4. Annualized Excess Productivity Cost of CAP

	Pneumonia		No Pneumonia		Excess Cost[a]
Method/type of loss	**Mean**	**SD**	**Mean**	**SD**	**Mean**
Observed, matched, unadjusted					
Absenteeism	$7817	$8060	$6928	$7352	$889
Short-term disability	$2461	$8000	$1156	$5312	$1304
Ordinary least-squares regression					
Absenteeism	$8129	$2079	$7267	$2079	$862
Short-term disability	$2641	$1881	$1171	$1070	$1469
Generalized linear model					
Absenteeism	$8281	$2575	$7364	$2290	$917
Short-term disability	$2734	$2158	$1260	$1298	$1474

CAP indicates community-acquired pneumonia; SD, standard deviation.
Sample sizes for analysis of absenteeism consisted of 4497 pneumonia patients and 13,491 matched controls.
Sample sizes for analysis of short-term disability consisted of 15,498 pneumonia patients and 46,494 matched controls.
[a]All excess cost estimates are statistically significant at $P < .001$.

adult non-elderly population, for a total of $10.6 billion. The first, the 95% confidence interval, captures the stochastic variation from our sample, and the second, the methods bounds, captures the variation from the application of alternative multivariate regression models. The 95% confidence interval for the total cost estimates is from $10.2 billion to $10.9 billion. The methods bounds range from $9.0 billion for the projections using OLS estimates to $13.1 billion for the projections using GLM estimates.

DISCUSSION

For the non-elderly adult US population, we used the MarketScan commercial claims database to estimate the incidence and economic burden of community-acquired pneumonia to be 4.9 cases per 1000 person years with a national cost of $10.6 billion. While CAP is widely recognized as an important public health problem, very few contemporaneous studies have focused on its incidence and costs. Comparisons

Table 5. 2010 Projections of Annualized Excess Direct Medical and Productivity Cost of CAP in US Adults Aged 18 to 64 Years

Method	Direct Medical Cost	Productivity Cost	Both Costs
Observed, matched, unadjusted			
Estimate	$8.47 billion	$2.08 billion	$10.55 billion
95% confidence interval	($8.38-$8.56 billion)	($1.86-$2.32 billion)	($10.24-$10.88 billion)
Methods bounds			
(OLS to GLM)	($6.83-$10.84 billion)	($2.21-$2.26 billion)	($9.04-$13.1 billion)

CAP indicates community-acquired pneumonia; GLM, generalized linear model; OLS, ordinary least squares.
Note: Estimates are based on Monte Carlo simulations with 10,000 trials each.

of our estimates are therefore very difficult, as we failed to find relevant references on incidence of CAP in the US population aged 18 to 64 years in the first decade of the 21st century. Nevertheless, the CAP incidence from our study is overall similar to that reported for adults in Spain and Germany in the 2000s (3.1 per 1000 person-years[11] and 3.7 to 10 per 1000 person-years,[12] respectively) or in Finland in the 1980s (6.0 per 1000 population)[13] but higher than most estimates (1.0 to 3.0 per 1000) reported in a recent review of European studies of CAP.[14]

Our national cost estimate of $10.6 billion includes $8.5 billion in direct medical costs and $2.1 billion in productivity costs. The medical cost projections are in line with projections from the 1990s after adjusting for medical CPI and after removing the non-elderly, but this is the first projection to include representative estimates of productivity costs.

On an episode basis, we estimated excess direct medical costs to be $8942 for the year following a pneumonia diagnosis, with $4204 incurred in the inpatient setting, $3774 in outpatient, and $964 in pharmacy. The high outpatient costs among CAP patients can be traced to the higher rates of ED visits, outpatient office visits, laboratory claims, and radiology claims in the post-period than their matched counterparts.

Using employee-level workplace absenteeism and short-term disability data, the observed excess productivity costs from a CAP diagnosis were $2193. For this population, productivity costs represent 20% of the $11,135 of total excess costs of CAP. Birnbaum et al performed a retrospective claims-based analysis of CAP based on employer payments for medical care, disability claims, and projections of short-term absenteeism made by a single Fortune 100 company from 1996 to 1998.[5] This analysis found that productivity costs of disability and absenteeism accounted for 29% of the total cost. The observed excess productivity loss associated with CAP was also considerably less than reported by small, non-representative, intervention-based studies by Palmer et al[15] and Orrick et al.[16]

The uncertainty in our estimates came from 2 sources. Despite the very large sample size of over 400,000 cases, there is some stochastic variation stemming from the fact that the cost distribution is highly skewed. Nevertheless, the 95% confidence interval for our estimate of direct medical costs is narrow, ranging from $8.4 to $8.6 billion. The greater source of uncertainty is a result of the covariate adjustment. Despite the matched cohort, there is sufficient imbalance between cases and controls to change the point estimates in the multivariate adjustment. What is somewhat surprising is that the GLM estimate of direct costs of CAP is higher than the unadjusted estimate of $10.8 billion and the OLS estimate of direct costs of CAP of $6.8 billion is lower than the unadjusted estimate of $8.5 billion. Given this wide sensitivity to the method of adjustment, it is important to consider our estimate of direct medical costs as ranging from $6.8 to $10.8 billion. The bounded estimate for total excess costs is $9.0 to $13.1 billion.

The analyses described herein have several limitations. The validity of the national excess cost of CAP relies on our assumption that incidence of CAP and its unit cost observed in our insured population were proxies for the remaining US population of similar age. While the MarketScan Commercial Database represents a wide variety of nationally representative employed patients and their dependents, it is not a random sample and does not include Medicaid enrollees or the uninsured. Nevertheless, given the fact that the vast majority of adults are insured through employer-sponsored health insurance, our extrapolations should be fairly accurate. Our estimates are based on average effects; we did not explore the possibility that excess costs might be higher in certain subgroups such as among those with COPD or in older age groups. This would be an important line of future research.

Misclassification of pneumonia due to inaccurate or absent diagnosis coding is possible when analyzing claims data. For example, it is possible that some mild cases were coded as "respiratory infection" and a few severe cases were coded as "sepsis." Likewise, the intention of this analysis was to describe the burden of CAP separate from HAP; our ability to differentiate CAP from HAP may be limited by information available in an administrative claims database. Including HAP cases in our cohort of CAP patients could lead to an overestimation

of the burden of CAP. Due to this limitation, incidence and costs may not be precise. A final caveat is that work absence data are limited because they include multiple and varied reasons for work loss, including illness, personal time, or vacation. The impact of these limitations is unclear but they do restrict the level of comparisons available.

In summary, the incidence of CAP in the population aged 18 to 64 years is relevant, with a projected 950,000 cases annually. After adjusting for systemic differences between patients with CAP and without CAP, we found that CAP in this population is associated with substantial direct medical cost and productivity losses estimated at $10 billion annually. Costs associated with lost productivity due to CAP are significant and should not be overlooked when evaluating the burden of CAP.

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REFERENCES

1. Trends in pneumonia and influenza morbidity and mortality. American Lung Association website. http://www.lungusa.org/finding-cures/our-research/trend-reports/pi-trend-report.pdf. Accessed January 2010.

2. Colice GL, Morley MA, Asche C, Birnbaum HG. Treatment costs of community-acquired pneumonia in an employed population. *Chest.* 2004;125(6):2140-2145.

3. Lave JR, Lin CJ, Fine MJ, Hughes-Cromwick P. The cost of treating patients with community-acquired pneumonia. *Semin Respir Crit Care Med.* 1999;20(3):189-197.

4. Niederman MS, McCombs JS, Unger AN, Kumar A, Popovian R. The cost of treating community-acquired pneumonia. *Clin Ther.* 1998;20(4):820-837.

5. Birnbaum HG, Morley M, Greenberg PE, Cifaldi M, Colice GL. Economic burden of pneumonia in an employed population. *Arch Intern Med.* 2001;161(22):2725-2731.

6. Consumer Price Index Detailed Report Tables, Annual Average 2008. US Bureau of Labor Statistics website. http://www.bls.gov/cpi/cpid08av.pdf. Accessed June 2009.

7. National Average Wage Index, Social Security Online. http://www.ssa.gov/oact/cola/AWI.html#Series. Accessed September 2011.

8. Goetzel RZ, Guindon AM, Turshen IJ, Ozminkowski RJ. Health and productivity management—establishing key performance measures, benchmarks and best practices. *J Occup Env Med.* 2001;43(1):10-17.

9. Crystal Ball [computer program]. Version 4.0. Denver, CO: Decisioneering; 1996.

10. Excel [computer program]. Version 2007. Redmond, WA: Microsoft Corporation; 2007.

11. Capelastegui A, España PP, Bilbao A, et al. Study of community-acquired pneumonia: incidence, patterns of care, and outcomes in primary and hospital care. *J Infect.* 2010;61(5):364-371.

12. Schnoor M, Hedicke J, Dalhoff K, Raspe H, Schäfer T; CAPNETZ study group. Approaches to estimate the population-based incidence of community acquired pneumonia. *J Infect.* 2007;55(3):233-239.

13. Jokinen C, Heiskanen L, Juvonen H, et al. Incidence of community-acquired pneumonia in the population of four municipalities in eastern Finland. *Am J Epidemiol.* 1993;137(9):977-988.

14. Welte T, Torres A, Nathwani D. Clinical and economic burden of community-acquired pneumonia among adults in Europe [published online ahead of print August 20, 2010]. *Thorax.* 2012;67(1):71-79.

15. Palmer CS, Zhan C, Elixhouser A, et al. Economic assessment of the community-acquired pneumonia intervention trial employing levofloxacin. *Clin Ther.* 2000;22(2):250-264.

16. Orrick JJ, Segal R, Johns TE, Russell W, Wang F, Yin DD. Resource use and cost of care for patients hospitalised with community acquired pneumonia: impact of adherence to Infectious Diseases Society of America guidelines. *Pharmacoeconomics.* 2004;22(11):751-757. ■