Hospitalized Community-acquired Pneumonia in the Elderly

Age- and Sex-related Patterns of Care and Outcome in the United States

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Community-acquired pneumonia (CAP) is a frequent cause of hospital admission and death among elderly patients, but there is little information on age- and sex-specific incidence, patterns of care (intensive care unit admission and mechanical ventilation), resource use (length of stay and hospital costs), and outcome (mortality). We conducted an observational cohort study of all Medicare recipients, aged 65 years or older, hospitalized in nonfederal U.S. hospitals in 1997, who met ICD-9-CM–based criteria for CAP. We identified 623,718 hospital admissions for CAP (18.3 per 1,000 population ⩾ 65 years), of which 26,476 (4.3%) were from nursing homes and of which 66,045 (10.6%) died. The incidence rose five-fold and mortality doubled as age increased from 65–69 to older than 90 years. Men had a higher mortality, both unadjusted (odds ratio [OR]: 1.21 [95% CI: 1.19–1.23]) and adjusted for age, location before admission, underlying comorbidity, and microbiologic etiology (OR: 1.15 [95% CI: 1.13–1.17]). Mean hospital length of stay and costs per hospital admission were 7.6 days and $6,949. For those admitted to the intensive care unit (22.4%) and for those receiving mechanical ventilation (7.2%), mean length of stay and costs were 11.3 days and $14,294, and 15.7 days and $23,961, respectively. Overall hospital costs were $4.4 billion (6.3% of the expenditure in the elderly for acute hospital care), of which $2.1 billion was incurred by cases managed in intensive care units. We conclude that in the hospitalized elderly, CAP is a common and frequently fatal disease that often requires intensive care unit admission and mechanical ventilation and consumes considerable health care resources. The sex differences are of concern and require further investigation.

Keywords: pneumonia; intensive care; health resources; cost; age; sex

Over the last decade, community-acquired pneumonia (CAP) has been the focus of many quality improvement and cost containment efforts (1–6). Most of these efforts have centered on reducing unnecessary care for low-risk, uncomplicated cases, possibly contributing to the reported decline in average hospital length of stay (LOS) for CAP (1, 6). There has been arguably less focus on the standardization of care for sicker, high-risk patients, such as the elderly or those requiring mechanical ventilation. One explanation may be the logistic difficulty of standardizing the more complex care required for sicker patients. It is also possible that there is less concern for inappropriate care in this group or that such patients represent only a small proportion of the total number of CAP cases. However, recent data indicate that in the elderly both the incidence and mortality of CAP are rising (7).

Other data suggest sex may also be an important determinant of incidence and mortality. In animal studies, female sex hormones seem protective in sepsis (8, 9). Clinical data, however, are conflicting. Crabtree and coworkers found women who develop nosocomial pneumonia fare worse than men after adjusting for age and severity of illness (10). Others found either no sex effect on mortality (11) or better outcomes in women (12).

These data raise important questions regarding the current care of patients hospitalized with CAP. We conducted a study of all hospitalized cases of CAP in 1997 among the Medicare population aged 65 years or older. The objective of our study was to provide a contemporary assessment of the incidence, patterns of care, and outcome of hospitalized CAP in the elderly U.S. population and to determine differences by age and sex.

METHODS

Data Sources

We linked four databases: a patient database (the 1997 Medicare Provider Analysis and Review hospital discharge database [MedPAR]; Centers for Medicare and Medicaid Services [CMS], Washington, DC); a population database (CB97–64, Population Estimates Program; U.S. Bureau of the Census, Washington DC); and two hospital databases (the 1997 Provider Specific File and Hospital Cost Report Minimum Dataset; CMS, Washington, DC). MedPAR contains all discharge records for Medicare beneficiaries using inpatient services at nonfederal acute-care hospitals or at skilled nursing facilities. MedPAR is created from Common Working File (CWF) claims records and validated through the National Claims History (NCH) Medicare Quality Assurance System (available at: www.cms.hhs.gov). For each discharge record, we selected age, sex, admission and discharge diagnosis and procedure codes (International Classification of Diseases, ninth revision, clinical modification [ICD-9-CM]) (13), source of admission, discharge status, hospital and intensive care unit (ICU) LOS, and hospital charges. To calculate costs, hospital charges were multiplied by the hospital-specific cost-to-charge ratio and expressed as 1997 U.S. dollars. We used 1997 U.S. census estimates to generate incidence rates (14).

Patient Selection

We selected all patients 65 years of age or older hospitalized in acute-care hospitals with a diagnosis of CAP. CAP was defined as either bacterial pneumonia (ICD-9-CM codes 481, 482, 485, or 486), listed both as the admission diagnosis and discharge diagnosis, or bacterial pneumonia, listed as a discharge diagnosis coupled with a pulmonary complaint at admission (respiratory failure [518.81], chronic obstructive pulmonary disease [COPD] [496], respiratory abnormality [786.09], complicated COPD [491.21], food/vomit pneumonitis [507.0], acute bronchitis [466.0], asthma without status asthmaticus [493.90], hemoptysis [786.3], or other pulmonary insufficiencies [518.82]). We excluded all patients transferred from other hospitals with the diagnosis of pneumonia (n = 7,300). We did not exclude nursing home resi-

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dents, a population included in the most recent official statement of the American Thoracic Society on "Guidelines for the Management of Adults with Community-acquired Pneumonia" (15).

Patient Classification

We organized patients by age, sex, location before hospital admission, microbiological etiology, and underlying illness, defined as a Charlson-Deyo comorbidity index greater than zero (16) (*see* Table E1 in online data supplement). We defined a "complex course" of pneumonia as one involving ICU admission or mechanical ventilation. We determined the incidence of nonpulmonary organ dysfunction using a previously developed ICD-9-CM-based scheme (17) and classified pulmonary complications using specific ICD-9-CM codes.

Data Analyses

We analyzed incidence, case number, comorbidity, distribution of complex cases, LOS, costs, overall mortality, and mortality within age and sex. We categorized baseline characteristics as needed. We present means and medians for continuous data and counts and rates for categorical data. Univariate analyses were conducted by Wilcoxon-Mann-Whitney test and by Chi-square test. We developed a generalized logit link (mathematical transformation) regression (18) for hospital mortality using all baseline characteristics as covariates. The model was constructed on one half of the data and validated on the other half. Performance was assessed by the likelihood ratio statistic (R^2_L) and the Hosmer-Lemeshow C statistic (19). Crude and adjusted odds ratios for mortality were recalculated for the entire cohort. We managed data using Visual FoxPro (Microsoft Corp, Redmond, WA) and conducted analyses using Data Desk (Data Description Inc, Ithaca, NY).

RESULTS

Nationwide, we identified 623,718 cases of hospitalized CAP in the elderly population. Pneumonia was diagnosed both at admission and discharge in 79.3% of the study cohort. The remaining 20.7% had a diagnosis of pneumonia at discharge coupled with a pulmonary complaint on admission. Characteristics of the entire study cohort are provided in Table 1. The mean age of the study population was 77 years. More than two thirds had an underlying disease, with congestive heart failure, chronic pulmonary disease, and diabetes mellitus reported most commonly. In more than two thirds of all cases, no specific microbiologic etiology was identified. Women comprised slightly more than half of the study cohort, were older (77.7 versus 76.2 years, $p < 0.001$), and were less likely to suffer from underlying illness (Charlson-Deyo comorbidity index 1.01 versus 1.18, $p < 0.001$). Men were more likely to suffer from gram-negative infections (14.3% versus 11.5%, $p < 0.001$) and less likely to have an unspecified etiology (71.5% versus 76.3%, $p < 0.001$).

Nursing home residents, who comprised almost 5% of the study cohort, were older (mean age 80 versus 76.8 years, $p <$

TABLE 1. BASELINE CHARACTERISTICS AND MORTALITY OF STUDY COHORT

		Mortality	
	Number of Cases (%)	Crude OR* (95% CI)	Adjusted OR*† (95% CI)
All	623,718 (100)		
Age, yr			
65–69	87,456 (14.0)	—	—
70–74	112,192 (18.0)	1.08 (1.05–1.12)	1.04 (1.01–1.07)
75–79	128,514 (20.6)	1.25 (1.22–1.29)	1.16 (1.12–1.19)
80–84	128,247 (20.6)	1.49 (1.45–1.54)	1.32 (1.28–1.36)
85–89	97,211 (15.6)	1.75 (1.70–1.81)	1.46 (1.42–1.51)
⩾ 90	70,094 (11.2)	2.15 (2.08–2.22)	1.75 (1.69–1.81)
Gender			
Female	334,469 (53.6)	—	—
Male	289,249 (46.4)	1.21 (1.19–1.23)	1.15 (1.13–1.17)
Prior residence			
Community	596,228 (95.7)	—	—
Nursing home	26,476 (4.3)	1.87 (1.81–1.93)	1.50 (1.44–1.55)
Comorbidity‡			
Congestive heart failure	198,813 (31.9)	1.82 (1.77–1.87)	1.53 (1.47–1.59)
Pulmonary disease	152,537 (24.5)	1.35 (1.32–1.39)	0.95 (0.93–1.00)
Diabetes mellitus	108,621 (17.4)	1.27 (1.23–1.31)	0.96 (0.93–0.99)
Malignancy	56,911 (9.1)	2.29 (2.22–2.36)	2.26 (2.20–2.33)
Neurologic disease	53,396 (8.6)	1.53 (1.48–1.59)	1.02 (0.99–1.05)
Myocardial infarction	33,350 (5.4)	2.17 (2.09–2.26)	1.53 (1.47–1.59)
Renal disease	16,795 (2.7)	2.94 (2.81–3.07)	2.15 (1.95–2.25)
Liver disease	3,569 (0.6)	2.69 (2.34–3.09)	2.10 (1.87–2.34)
Etiology§			
Streptococcus pneumoniae	33,451 (5.4)	0.86 (0.82–0.90)	0.93 (0.90–0.97)
Hemophilus influenzae	18,849 (3.0)	0.55 (0.51–0.60)	0.69 (0.65–0.73)
Staphylococcus species	31,281 (5.0)	2.07 (2.00–2.13)	1.85 (1.77–1.92)
Enteric gram-negatives	59,960 (9.6)	1.30 (1.26–1.33)	1.21 (1.18–1.25)
Pseudomonas species	28,492 (4.6)	1.58 (1.52–1.64)	1.47 (1.41–1.52)

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

* Age 65–69 yr, female, prior residence in community, no comorbid illness, and no etiology specified were used as reference categories.

† Adjusted odds ratios were calculated using a generalized logit link model (model performance: *see* text).

‡ Comorbidity was defined according to the Charlson-Deyo comorbidity index.

§ Viral, mycoplasmal and chlamydial pneumonia specified by ICD-9-CM codes comprised less than 1.5% of all cases and were not included in the study cohort.

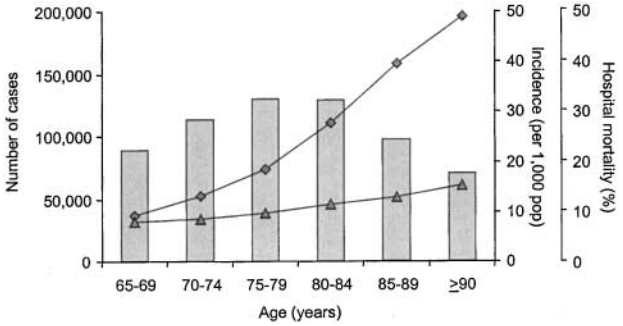

Figure 1. Age-specific number of cases, incidence, and hospital mortality for hospitalized community-acquired pneumonia. Patient data are generated from the HCFA 1997 Medicare discharge database and represent only cases 65 years of age or older. Incidence (*diamonds*) and hospital mortality (*triangles*) both rose with age across all age groups ($p < 0.001$). The number of cases fell beyond 80 years because of the age distribution of the underlying population. ▢ Number of cases.

0.001), more likely to be women (58.1% versus 53.4%, $p < 0.001$), more likely to suffer from underlying illness (Charlson-Deyo comorbidity index 1.09 versus 1.22, $p < 0.001$), and less likely to have an etiology specified (67.5% versus 70.6%, $p < 0.001$). The frequency of gram-negative enteric infections among nursing home residents was slightly higher than for the remainder of the cohort (10.1% versus 9.6%, $p < 0.001$).

Generally, those listed with pneumonia at discharge only were similar to those diagnosed with pneumonia at both discharge and admission (mean age 75.5 versus 77.3 years, $p < 0.001$; male 48.1% versus 46.1%, $p < 0.001$; Charlson-Deyo comorbidity index 1.13 versus 1.08, $p < 0.001$; no etiology specified 66.2% versus 71.5%, $p < 0.001$; enteric gram-negative etiology 9.9% versus 9.5%, $p < 0.001$), although differences remained significant because of large sample size.

Incidence

The incidence of hospitalized CAP in those 65 years of age or older was 18.3 cases per 1,000 population. The age-specific number of cases and incidence are shown in Figure 1. The incidence rose more than five-fold with age from 8.4 per 1,000 in those aged 65–69 years to 48.5 per 1,000 in those aged 90 years and older. The number of cases, however, fell beyond age 80 because of the age distribution of the underlying population. Although there were more women in the study cohort, the incidence rate was higher in men (19.4 versus 15.6 cases per 1,000 population, $p < 0.001$). This higher incidence persisted across all age groups such that men had an incidence similar to that of women five years older (Figure 2).

Hospital Course

We identified 140,226 complex cases, of whom 95,589 (68.2%) received ICU care alone, 41,355 (29.5%) received ICU care and mechanical ventilation, and 3,282 (2.3%) received mechanical ventilation outside the ICU, presumably in intermediate care facilities. Overall, complex cases represented 22.5% of the entire cohort. Younger cases were more likely to be complex, with the proportion dropping from 26.7% in those aged 65–69 years to 14.7% in those aged 90 years and older (Figure 3). Men were also more likely to be managed with a complex course, both overall (24.4% versus 20.8%, $p < 0.001$) and across all age groups (Figure 2). Not surprisingly, patients who incurred a complex course were more likely to have underlying disease (Charlson-Deyo comorbidity index 1.26 versus 1.05, $p < 0.001$) and to develop pulmonary complications (12.8% versus 8.3%, $p < 0.001$) or nonpulmonary organ dysfunction (7.6% versus 4.7%, $p < 0.001$) (Table 2).

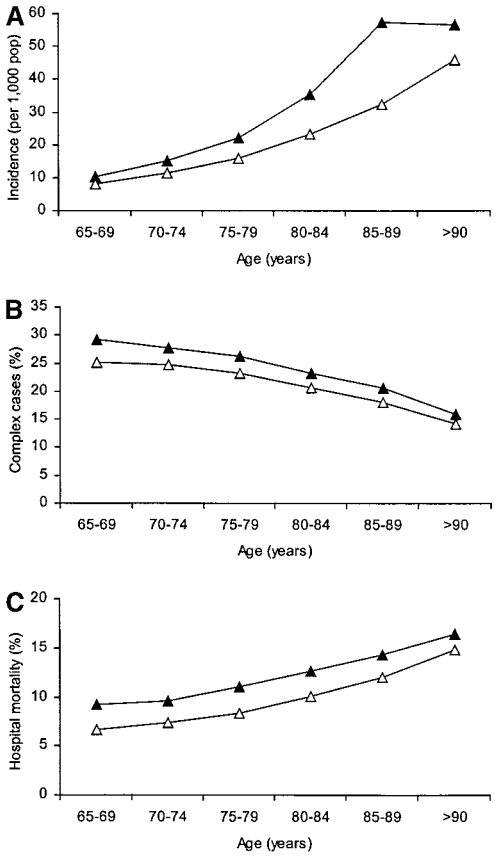

Figure 2. Age- and sex-specific incidence, course, and outcome of hospitalized community-acquired pneumonia. Men (*closed triangles*) had higher incidence (*top*), higher proportion of cases that were complex (*middle*), and higher mortality (*bottom*) than women (*open triangles*). Differences were statistically significant across all age groups ($p < 0.001$).

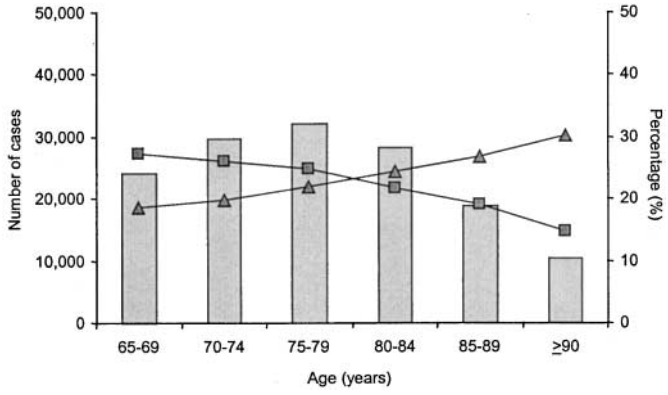

Figure 3. Age-specific number, occurrence rate, and hospital mortality for complex cases in hospitalized community-acquired pneumonia. Complex pneumonia was defined as one involving ICU care or mechanical ventilation. Occurrence rate of complex cases decreased and hospital mortality increased for each age group ($p < 0.001$). ▢ Number of complex cases; ■ occurrence rate; ▲ hospital mortality.

TABLE 2. OCCURRENCE AND MORTALITY OF PULMONARY AND NONPULMONARY COMPLICATIONS IN SIMPLE AND COMPLEX COURSE* OF HOSPITALIZED COMMUNITY-ACQUIRED PNEUMONIA

	Occurrence n (%)		Mortality Crude OR† (95% CI)	
Hospital Course	Simple (*n = 483,492*)	Complex (*n = 140,226*)	Simple (*n = 34,524*)	Complex (*n = 31,521*)
Acute organ dysfunction‡				
Respiratory	—	44,637 (31.8)	—	7.7 (7.5–7.8)
Renal	5,758 (1.2)	9,566 (6.8)	7.7 (7.3–8.2)	4.4 (4.2–4.6)
Cardiovascular	5,836 (1.2)	9.342 (6.7)	4.2 (3.9–4.4)	4.2 (3.8–4.6)
Hematologic	7,125 (1.5)	4.732 (3.4)	1.7 (1.5–1.9)	1.7 (1.5–1.9)
Neurologic	3,587 (0.8)	2.764 (2.0)	1.2 (1.0–1.5)	1.2 (1.1–1.5)
Hepatic	112 (> 0.1)	269 (0.2)	11.3 (7.8–16.4)	8.4 (5.4–13.0)
Number of organs with acute dysfunction				
1	20,822 (4.3)	41,780 (29.8)	3.3 (3.2–3.5)	3.6 (3.5–3.7)
2	770 (0.2)	11,116 (8.0)	10.2 (8.8–11.8)	8.8 (8.5–9.2)
⩾ 3	18 (> 0.1)	2,315 (17)	18.3 (6.8–49.3)	18.6 (16.8–20.5)
Pulmonary complications§				
Effusion	27,729 (5.7)	10,581 (7.5)	1.3 (1.2–1.4)	1.1 (1.0–1.2)
Atelectasis	12,863 (2.7)	6,289 (4.5)	0.9 (0.8–1.0)	0.9 (0.8–1.0)
Pneumothorax	1,099 (0.2)	1,775 (1.3)	2.4 (1.9–2.8)	2.7 (2.3–3.0)
Emphysema	1,004 (0.2)	1,117 (0.8)	1.5 (1.3–2.1)	1.1 (0.9–1.3)
Lung abscess	673 (0.1)	409 (0.3)	1.3 (1.0–1.9)	1.6 (1.2–2.3)
Any complication	40,284 (8.3)	17,881 (12.8)	1.2 (1.1–1.3)	1.2 (1.1–1.3)

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

* A complex course of pneumonia was defined as one involving ICU admission or mechanical ventilation.

† No pulmonary complication and no acute organ dysfunction were used as reference categories.

‡ Acute organ dysfunction was defined using an ICD-9-CM-based scheme as respiratory (mechanical ventilation [96.7]), renal (acute renal failure [584]), cardiovascular (shock without trauma [785], hypotension [485]), hematologic (secondary thrombocytopenia [287.4], unspecified thrombocytopenia [287.5], other/unspecified coagulation defect [286.9], defibrination syndrome [286.6]), neurologic (encephalopathy [293], transient organic psychosis [348.1], anoxic brain damage [348.3]), and hepatic (acute and sub-acute necrosis of liver [570], hepatic infarction [573.4]).

§ Pulmonary complications were classified using ICD-9-CM codes as effusion (511.1, 511.8, 511.9), atelectasis (518.0), pneumothorax (512), empyema (510.9), lung abscess (513.0).

Mortality

The hospital mortality for the entire cohort was 10.6% (n = 66,045). Hospital mortality doubled with age from 7.8% in those aged 65–69 years to 15.4% in those aged 90 years and older (Figure 1). Mortality was higher in nursing home residents (17.6 versus 10.3%, $p < 0.001$). Mortality was also higher in patients with an underlying illness (11.9% versus 7.6%, $p < 0.001$) and varied with microbiologic etiology. Mortality was higher in men than in women, both overall (11.6% versus 9.8%, $p < 0.001$) and within age groups (Figure 2). Crude odds ratios for mortality for different baseline characteristics are provided in Table 1. The mortality model performed well with the link parameter set at 15 ($R^2_L = 64.8$, Hosmer-Lemeshow C statistic = 31.0 [8 df], and area under the receiver operating characteristic [ROC] curve = 0.654 [maximal ROC for data = 0.6786] for the development set, and $R^2_L = 64.98$ and Hosmer-Lemeshow C statistic = 66.0 [8 df] for the validation set). In the validation cohort, there were 33,114 actual deaths and 33,076 predicted deaths (standardized mortality ratio = 0.999 [95% CI 0.985–1.014]). Odds ratios for mortality adjusted for baseline characteristics are provided in Table 1. As expected, increasing age, residence in a nursing home, and comorbidity remained significant predictors of death after adjustment. Adjusted odds for death were also increased for men, although this effect was small (OR: 1.15, 95% CI 1.13–1.17).

Crude odds ratios for mortality of pulmonary and nonpulmonary complication for simple and complex course of pneumonia are provided in Table 2. Not surprisingly, patients with a complex course of pneumonia had a much higher mortality (22.5% versus 7.1% for complex versus simple course, $p < 0.001$), as did patients developing acute organ dysfunction (23.2% versus 9.9% for any organ dysfunction versus no organ dysfunction, $p < 0.001$). Of note, mortality for patients 90 years of age and older was 15.4% overall, 30.2% for complex cases, and 55.4% for those receiving mechanical ventilation.

Most deaths occurred early, with one out of four (n = 18,023) occurring within 48 hours of hospital admission (Figure 4). Patients dying early during the hospital course were older (79.6 versus 78.3, $p < 0.001$) and more likely to be nursing home residents (8.2% versus 6.7%, $p < 0.001$).

Resource Use and Costs of Care

Mean LOS and cost per hospital admission were 7.6 days and $6,949. Patients with a complex course, especially those receiving mechanical ventilation, had much higher LOS and costs (Table 3). There was a small decrease in LOS and a large decrease in costs with age (7.7 days and $7,768 for those aged 65–69 years versus 7.4 days and $5,683 for those aged 90 years and older, $p < 0.001$ for both comparisons), mainly due to a higher proportion of complex cases in younger patients (26.7% for those aged 65–69 years versus 14.7% for those over 90 years of age, $p < 0.001$). Mean LOS was similar for men and women (7.6 versus 7.7 days) but mean costs were higher for men ($7,206 versus $6,726, $p < 0.001$), mainly due to the higher likelihood for men to be managed with a complex course (24.4% versus 20.8%, $p < 0.001$). Overall, nonsurvivors had higher LOS and costs compared with survivors (9.1 and $11,795 versus 7.5 and $6,375, respectively, $p < 0.001$ for both comparisons), primarily because nonsurvivors were more likely to incur complex courses.

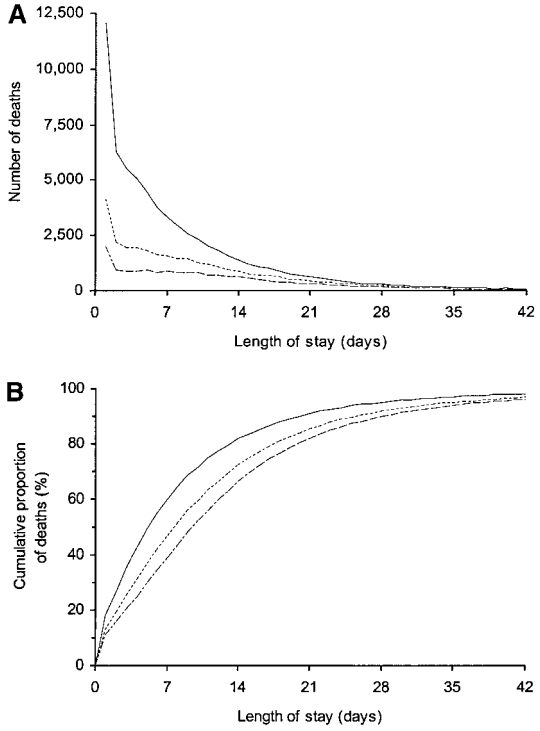

Figure 4. Distribution of hospital deaths over time. The *upper panel* shows the number of deaths and the *lower panel* shows the cumulative proportion of deaths over the length of hospital stay. Day one includes all cases that had less than two daily hospital census counts. The time axis is truncated at day 42 of hospital stay, after which a residual of 1.8% of deaths occurred. The most common day of death was day one, both overall (17.9%) and for subgroups managed aggressively (12.8% for complex cases and 10.8% for cases on mechanical ventilation). ——— All cases; - - - - - complex cases; — - - — cases on mechanical ventilation.

Burden of Hospitalized CAP on the Medicare Hospital Budget

In 1997, Medicare covered 34 million Americans. During that year, there were 10 million acute care hospital admissions, accounting for 69 million hospital days, 8.5 million ICU days, $70 billion hospital costs, and 536,173 hospital deaths. Patients hospitalized with CAP accounted for 6.2% of admissions (623,718), 6.3% of costs ($4.4 billion), 7% of hospital days (4.8 million), 7.4% of ICU days (633,232), and 12.3% of hospital deaths (66,044). The percentage of hospital admissions attributable to CAP increased with age from 4.5% in those aged 65–69 years to 9.7% for those aged 90 years and older. One out of five cases had a complex course, and half of the hospital costs attributable to hospitalized CAP ($2.1 billion) were incurred by patients with a complex course. Expenses for nonsurvivors totaled $779 million, of which 73.8% were spent in nonsurvivors of ICU care.

DISCUSSION

Our study reinforces prior findings (20, 21) that CAP is a major clinical problem in the U.S. and further suggests that the burden of this disease will grow substantially in the coming years. Many patients hospitalized with CAP were very sick, as evidenced by the common use of intensive care, life support, and the high mortality rates. Even in the oldest patients, there was a strong commitment to provide aggressive care. We also present new information on important variations in process of care and outcome by age and sex. Men were more likely to be hospitalized with CAP, more likely to receive intensive care or life support, and more likely to die.

Assuming the U.S. census projected population estimates and a constant age-specific incidence of hospitalized CAP, we forecast the annual number of cases to rise to 750,000 in the year 2010, and 1 million in the year 2020, due to the disproportionate growth of the elderly population.

To initiate mechanical ventilation for a 90-year old patient with pneumonia may seem aggressive or even excessive. Yet we found such care was provided commonly and that almost half of the patients older than 90 years who received mechanical ventilation were discharged alive, supporting the belief that such care for the critically ill elderly patient is often justified (22, 23). It is probable, however, that many factors other than the patient's severity of respiratory failure influence the decision to initiate mechanical ventilation. A decrease in hospital costs with age, which was due to a lower proportion of complex cases in the oldest patients, was not explained by less severe disease. Presumably, therefore, it reflected greater use of advanced directives or limitations on care. Certainly, the decision to provide intensive care varied widely in prior studies of patients with CAP (24, 25), raising the possibility that the decision to provide intensive care or life support may be strongly influenced by local practice pat-

TABLE 3. RESOURCE USE IN SIMPLE AND COMPLEX* COURSE OF HOSPITALIZED COMMUNITY-ACQUIRED PNEUMONIA

	Simple Pneumonia (*n = 483,492*)	Complex Pneumonia (*n = 140,226*)	Mechanical Ventilation (*n = 44,637*)	All (*n = 623,718*)
Hospital LOS, d (mean ± SD, median)				
All	6.6 ± 5.3 (5)	11.3 ± 12 (8)	15.7 ± 15.3 (12)	7.6 ± 7.6 (6)
Survivors	6.6 ± 5.0 (5)	11.0 ± 11 (8)	16.9 ± 14.7 (13)	7.5 ± 6.9 (6)
Nonsurvivors	6.4 ± 8.2 (4)	12.0 ± 15 (8)	13.9 ± 16.2 (10)	9.1 ± 12 (6)
Hospital cost, $ (mean ± SD, median)				
All	4,818 ± 4,168 (3,754)	14,294 ± 18,359 (8,725)	23,961 ± 24,644 (17,087)	6,949 ± 10,242 (4,326)
Survivors	4,784 ± 3,933 (3,768)	12,947 ± 16,160 (8,274)	24,159 ± 23,828 (17,290)	6,375 ± 8,592 (4,245)
Nonsurvivors	5,273 ± 6,481 (3,475)	18,938 ± 23,896 (11,386)	23,675 ± 25,775 (16,696)	11,795 ± 18,467 (5,678)

Definition of abbreviations: LOS = length of stay; n = number of cases; SD = standard deviation.
* Complex course of pneumonia was defined as one involving ICU admission or mechanical ventilation.

terns. Just as prior efforts have sought to standardize and improve the hospital admission decision (2, 4, 26, 27), we recommend efforts to standardize and improve decisions to provide intensive care and life support. A better understanding of the long-term survival and quality of life after complex hospital care for these patients will also be essential.

The differences we observed between men and women are consistent with animal (8, 9) and human (12) studies suggesting that females are less likely to develop sepsis or to die from it but conflict with those observed in nosocomial pneumonia (10). The reasons for these discrepancies are not clear. Prior clinical studies were from single centers without population-based incidence rates, potentially leading to selection bias. Sex differences may not simply be due to biologic differences but also to many other factors, such as access to care (28). For example, a sex bias in the hospital admission decision could both explain the reduced incidence of hospitalized CAP in women and confound interpretation of hospital mortality rates. Further research on sex differences should focus on differences in both the biological response to infection and patterns of health care delivery.

The large number of deaths on day one of hospital admission is of concern. Presumably, the decision to hospitalize implies that a patient can receive elements of care that improve outcome yet cannot be provided easily elsewhere (e.g., intravenous antibiotics, life support, or certain diagnostic tests). Many of these elements of care are not expected to reverse a patient's course in one day. Some of the early hospital deaths, therefore, might have been averted had patients been hospitalized sooner. In other instances, death may have been considered inevitable and preceded by withdrawal of support. If so, it may have been more appropriate to avoid hospital admission in the first place. In other words, the high number of early deaths suggests many patients received hospital care that was either too late or inappropriate. Currently, the focus on improving the hospital admission decision has been limited to decreasing hospital care for low risk cases (2, 4). We recommend expanding that focus to explore earlier hospitalization for high-risk patients and better options for patients requiring end-of-life care.

Our study has limitations. We relied on administrative data, which are restricted in quality and detail (29). This may have resulted in incorrect identification of patients with CAP. However, using selection criteria based on both the admission diagnosis and all discharge diagnoses minimized inclusion of nosocomial pneumonia (a confounder in prior ICD-9-CM–based CAP studies) and avoided exclusion of patients with a complicated course, where the principal discharge diagnosis was not pneumonia (e.g., respiratory failure or tracheotomy). Patients who had a pulmonary complaint as reason for hospital admission and who developed pneumonia in the hospital (e.g., COPD) might have been misclassified as CAP. However, such misclassification was unlikely, especially in surgical patients—the group at highest risk for nosocomial pneumonia—because surgery is often postponed when surgical patients have pulmonary complaints. The data curtailed our ability to assess the extent to which differences in severity of illness explained differences in mortality rates. The data also restricted our exploration of processes of care, such as the use and timing of different procedures (e.g., bronchoscopy). The high incidence of pneumonia that was either unspecified or attributed to gram-negative organisms might have been due in part to coding biases. If our study cohort had included patients from Veteran Administration hospitals, which account for 5% of all U.S. hospital admissions and the majority of whom are males, our finding of a higher incidence of pneumonia in men would have been further magnified. Although hospital-specific cost-to-charge ratios have been shown to compare well to detailed cost accounting methods for estimating true costs (30), we did not capture the cost of physician services, outpatient services, and home health care services, which account for roughly one quarter of the total cost for a hospitalized pneumonia episode (31). By extrapolation, a more comprehensive estimate of the national costs for hospitalized CAP in the elderly population would be $6.4 billion. Despite these limitations, administrative data provide a valuable opportunity to understand population-based information on incidence, patient characteristics, delivery of care, outcome, and resource use.

In conclusion, hospitalized CAP in the elderly is a common, expensive, and frequently fatal disease. There were considerable differences between men and women, which require further investigation. A quarter of all patients required intensive care or life support. Therefore, optimal care must include a focus on early, appropriate decision-making, not only regarding hospital admission, but also regarding the use of intensive care services. The anticipated growth of the elderly U.S. population will dramatically increase the national burden of this disease in the near future.

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