Trends in Hospitalizations for Pneumonia Among Persons Aged 65 Years or Older in the United States, 1988-2002

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Pneumonia is among the 10 leading causes of death in the United States and is a significant cause of outpatient visits and hospitalizations. Several studies suggest that the rates of hospitalization for pneumonia may be increasing among US adults, particularly among older adults (patients aged ≥65 years). While increasing age is associated with higher disease rates, few studies have explored trends according to age groups and occurrence of pneumonia. Factors that increase the risk for pneumonia include the presence of underlying medical conditions, advanced age, functional disability, and residency in long-term care facilities; however, the reasons for the increasing trends in hospitalizations for pneumonia have not been well-defined. We hypothesized that an increase in chronic underlying conditions (reflected in increased comorbid diagnoses) could contribute to greater hospitalization rates for pneumonia over time.

To test this hypothesis, we used data from the National Hospital Discharge Survey (NHDS) to study trends according to age groups in hospitalization rates for pneumonia during a 15-year period (1988-2002) among US residents aged 65 years or older. The characteristics, outcomes, and comorbid disease diagnoses of patients with a hospital discharge diagnosis of pneumonia were compared with those of patients for editorial comment see p 2760.
with a hospital discharge diagnosis for other causes during the study period.

**METHODS**

Hospital discharge NHDS data from 1988-2002 for patients aged 65 years or older were obtained from the National Center for Health Statistics, Centers for Disease Control and Prevention. The NHDS is a representative sample of patient discharge records from short-stay, nonfederal general and children’s hospitals in the United States exclusive of federal, military, and Department of Veterans Affairs hospitals. Discharge data are collected by month for approximately 270,000 inpatient records from approximately 500 hospitals. The sampling design assigns a discharge weight to each hospital record. The discharge weight is the number of hospitalizations that the hospital record represents, and use of these weights permits calculations of nationally representative hospitalization estimates. The unit of analysis was a hospitalization, not an individual patient.

We defined a hospitalization for pneumonia as a record with ICD-9-CM codes 480 to 486 or 487.0 for pneumonia among any 1 of up to 7 discharge diagnoses. We examined hospitalization trends by both first-listed and any-listed ICD-9-CM discharge codes for pneumonia and for all causes. We assumed first-listed discharge codes for pneumonia represented hospital admissions due to pneumonia and that any-listed discharge codes represented a combination of hospital admissions precipitated by pneumonia (eg, exacerbations of underlying chronic conditions, such as congestive heart failure and chronic obstructive disease, caused by pneumonia) and secondary or nosocomial pneumonia. We examined hospitalization rates for all causes as a measure of overall hospitalization trends and practices.

The number of hospitalizations and hospitalization rates were evaluated by year, by age group (65-74 years, 75-84 years, and ≥85 years) and sex, and by 2 study periods (1988-1990 and 2000-2002). The 2 study periods were used to minimize the effect of year-to-year variability for estimates from the NHDS, to achieve sufficient numbers of hospitalizations for reliable estimates for certain comorbid conditions (ie, liver disease and metabolic diseases), and to enable consistent presentation of data. Race/ethnicity was not assessed because race was not reported on 18% of the discharge records. Hospitalization rates were calculated using denominators from US census estimates. Rates were expressed as the number of estimated hospitalizations per 1000 population. SUDAAN software version 7.0 (Research Triangle Institute, Research Triangle Park, NC) was used to calculate annual SEs and 95% confidence intervals (CIs) for hospitalization estimates to account for the stratified sampling techniques. Denominators were considered free from sampling error. Tests for trend during 1988-2002 were performed for annual hospitalization rates by using weighted least squares regression.

To test the hypothesis that chronic underlying illnesses contributed to increasing pneumonia hospitalization rates, we examined other discharge code diagnoses among patients hospitalized with pneumonia as the first-listed diagnosis. Comorbid diagnoses were classified into the following categories: chronic cardiac disease (ICD-9-CM codes 093, 391-398, 402, 404, 410-414, 416, 417, 421, 423-425, 427.1-427.5, 427.8, 428, 429, 440, 466, 745-747, V421, V450, V458.1, V458.2, 130.3, 112.8), chronic pulmonary disease (ICD-9-CM codes 011, 012, 031.0, 135, 277.0, 277.6, 491-496, 500-506, 507.0, 507.1, 508, 510, 513-519, 748.4-748.6, 7593, 770.2, 770.7, V426), diabetes mellitus (ICD-9-CM codes 250, 251, 648.0, 357.2, 362.0, 362.11, 366.11), neuro/musculoskeletal (ICD-9-CM codes 290, 294.1, 318.1, 318.2, 330, 331, 333.0, 333.4-333.9, 334, 335, 340-343, 344.0, 358.0, 358.1, 359.1, 359.2, 438, 756.4), malignancies (ICD-9-CM codes 140-208), chronic renal disease (ICD-9-CM codes 403, 581-583, 585-587, 588.0, 588.1, 590.0, 593.8, V420, V451, V56), immunosuppressive (ICD-9-CM codes 042-044, 079.5, 136.3, 279, 288.0, 288.1, 288.2, 446, 710.0, 710.2, 710.4, 714, V08, V420-V422, V426-V429, V580, V581), hemoglobinopathies (ICD-9-CM codes 282-284), liver disease (ICD-9-CM codes 571, 572.1-572.8), metabolic diseases (ICD-9-CM codes 255, 270, 271, 277.2, 277.3, 277.5, 277.8), and obesity (ICD-9-CM codes 278.00, 278.01).

Deaths that were recorded during hospitalization also were examined. The inhospital mortality ratios for first-listed and any-listed ICD-9-CM codes for pneumonia were compared with the ratios for hospitalizations for the 10 most frequent first-listed discharge diagnoses (excluding pneumonia) among patients aged 65 years or older in 2002. These 10 most frequent discharge diagnoses other than pneumonia were heart disease, cerebrovascular disease, malignant neoplasms, fractures, osteoarthritis and related disorders, chronic bronchitis, volume depletion, psychoses, septicemia, and diabetes mellitus.

Comparisons of rates by demographic characteristics and by the study periods of 1988-1990 and 2000-2002 were made with 2-sided t tests incorporating weighted variance estimates. A weighted Cochran-Mantel-Haenszel χ² test was used to compare proportions. Rate ratios and 95% CIs also were calculated to determine the relative percentage change in hospitalization rates and in the percentage of hospitalizations between 1988-1990 and 2000-2002.

Participation by hospitals in the National Center for Health Statistics surveys is voluntary and confidentiality of all information was ensured by the Public Health Service Act. Because the NHDS public data files do not include personal identifiers, this study was determined to be exempt from review by the institutional review board of the Centers for Disease Control and Prevention.

**RESULTS**

From 1988 through 2002, approximately 173 million (SE, 4.96 million) hospitalizations for all causes were es-

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Estimated for patients aged 65 years or older. Of these, 5.8% had pneumonia as the first-listed discharge diagnosis and 9.1% had pneumonia as any of the listed discharge diagnoses. The rates for first-listed and any-listed discharge diagnosis of pneumonia for patients aged 65 years or older increased similarly during the 15-year study period (FIGURE 1A). After stratification by age group, the trend toward increased rates of first-listed discharge diagnosis of pneumonia persisted for patients aged 65 to 74 years and aged 75 to 84 years but not for patients aged 85 years or older (Figure 1B). This is further illustrated when the rates of first-listed and any-listed discharge diagnosis of pneumonia for patients aged 65 years or older for 1988-1990 are compared with rates for 2000-2002 (TABLE 1). Similar to the yearly data, the rates increased significantly for patients aged 65 to 74 years and aged 75 to 84 years but not for patients aged 85 years or older. Patients aged 85 years or older had rates of hospitalization for pneumonia approximately 2-fold to 4-fold higher than in the other 2 age groups. The increase in hospitalizations for pneumonia during the study period was significant for both men and women. By comparison, the rates of hospitalization for all causes were not significantly different for 1988-1990 and 2000-2002 for patients aged 65 years or older.

We compared the rates of hospitalization by pneumonia ICD-9-CM codes from 1988-1990 to 2000-2002. During the study period, 71% of hospitalizations for pneumonia were categorized as "pneumonia with no specified organism" (ICD-9-CM code 486) and the rates of hospitalization with this code as the first-listed discharge diagnosis increased from 11.1 per 1000 population in 1988-1990 to 17.9 per 1000 population in 2000-2002 (P < .001). Hospitalization rates for other discharge diagnostic codes decreased: "pneumococcal pneumonia" (ICD-9-CM code 481) from 1.0 per 1000 population to 0.6 per 1000 population (P = .004); "other bacterial pneumonia, including gram negative rods and Staphylococcus aureus" (ICD-9-CM code 482) from 4.0 per 1000 population to 2.7 per 1000 population (P < .001); "bronchopneumonia, organism unspecified" (ICD-9-CM code 485) from 0.7 per 1000 population to 0.3 per 1000 population (P < .001); and "influenza with pneumonia" (ICD-9-CM code 487.0) from 0.2 per 1000 population to 0.1 per 1000 population (P = .09). The rates for "viral pneumonia excluding influenza" (ICD-9-CM code 480) did not change between periods. The number of hospitalizations for "pneumonia due to Mycoplasma, Chlamydia, or other specified organisms" (ICD-9-CM code 483) and "pneumonia in infectious diseases classified elsewhere, ie, whooping cough, aspergillosis, systemic mycosis, etc" (ICD-9-CM code 484) were too small to be reliable. The rate differences among any-listed discharge codes for pneumonia were similar to those seen among first-listed discharge codes for pneumonia.

Among older adults, at least 1 underlying medical condition was reported on most records with a first-listed discharge diagnosis of pneumonia (TABLE 2). Chronic cardiac disease, chronic pulmonary disease, and diabetes mellitus were the 3 underlying medical conditions most commonly reported, and the proportion of those hospitalized for pneumonia and diagnosed as having at least 1 of these conditions increased in 2000-2002 compared with 1988-1990. Proportions of records with first-listed discharge diagnosis for pneumonia and at least 1 of these 3 comorbid diagnostic categories increased from 66% (SE, 1.0%) in

**Figure 1.** Trends in Annual Rates of Hospitalizations of Persons Aged 65 Years or Older With Pneumonia as the First-Listed or Any-Listed Discharge Diagnosis

Data are based on National Hospital Discharge Survey estimates for the United States for 1988-2002; error bars indicate 95% confidence intervals. In A, among persons aged 65 years or older, P < .001 for trend for pneumonia as the first-listed diagnosis and P < .001 for trend for pneumonia as the any-listed diagnosis. In B, rates are for first-listed diagnosis of pneumonia; P < .001 for trend for persons aged 65 to 74 years, P < .001 for trend for persons aged 75 to 84 years, and P = .26 for trend for persons aged 85 years or older.

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1988-1990 to 77% (SE, 0.8%) in 2000-2002, a 16% increase (95% CI, 13%-20%). Twenty-seven percent (SE, 0.9%) had both chronic cardiac and lung disease listed and 6% (SE=0.3%) had all 3 categories listed as discharge diagnoses in 2000-2002. Other comorbid diagnostic categories, such as neuro/musculoskeletal and malignancies, were

Table 1. Characteristics of US Hospitalizations With Pneumonia as the First-Listed or Any-Listed Diagnosis and Hospitalizations for All Causes Among Patients Aged 65 Years or Older*

<table>
<thead>
<tr>
<th>Type of Hospitalization</th>
<th>1988-1990</th>
<th>2000-2002</th>
<th>Rate Change, % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-listed diagnosis of pneumonia</td>
<td>1 583 497</td>
<td>2 309 094</td>
<td>29 (15 to 44)</td>
</tr>
<tr>
<td>Age group, y</td>
<td>65-74</td>
<td>525 205</td>
<td>665 825</td>
</tr>
<tr>
<td></td>
<td>75-84</td>
<td>626 164</td>
<td>967 976</td>
</tr>
<tr>
<td></td>
<td>≥85</td>
<td>432 128</td>
<td>675 293</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>787 219</td>
<td>1 046 816</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>796 278</td>
<td>1 262 278</td>
</tr>
<tr>
<td>Any-listed diagnosis of pneumonia</td>
<td>2 472 410</td>
<td>3 726 047</td>
<td>30 (17 to 43)</td>
</tr>
<tr>
<td>Age group, y</td>
<td>65-74</td>
<td>829 201</td>
<td>1 091 657</td>
</tr>
<tr>
<td></td>
<td>75-84</td>
<td>995 323</td>
<td>1 552 366</td>
</tr>
<tr>
<td></td>
<td>≥85</td>
<td>647 886</td>
<td>1 082 024</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>1 229 213</td>
<td>1 693 372</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1 243 197</td>
<td>2 032 675</td>
</tr>
<tr>
<td>All causes</td>
<td>30 709 081</td>
<td>37 648 716</td>
<td>6 (−3 to 15)</td>
</tr>
</tbody>
</table>

Table 2. Comorbid Diagnostic Categories Reported With First-Listed Discharge Diagnosis of Pneumonia Among Patients Aged 65 Years or Older*

<table>
<thead>
<tr>
<th>Comorbid Diagnostic Category†</th>
<th>1988-1990</th>
<th>2000-2002</th>
<th>Change in Proportion of Total, % (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic cardiac disease</td>
<td>756 696</td>
<td>1 314 765</td>
<td>56.9 (0.9)</td>
</tr>
<tr>
<td>Chronic pulmonary disease</td>
<td>553 005</td>
<td>1 089 656</td>
<td>47.2 (1.0)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>204 514</td>
<td>451 105</td>
<td>19.5 (0.6)</td>
</tr>
<tr>
<td>Neuro/musculoskeletal</td>
<td>182 855</td>
<td>220 204</td>
<td>9.5 (0.5)</td>
</tr>
<tr>
<td>Malignancies</td>
<td>140 998</td>
<td>177 994</td>
<td>7.7 (0.3)</td>
</tr>
<tr>
<td>Chronic renal disease</td>
<td>73 135</td>
<td>150 556</td>
<td>6.5 (0.3)</td>
</tr>
<tr>
<td>Immunosuppressive</td>
<td>44 099</td>
<td>67 906</td>
<td>2.9 (0.2)</td>
</tr>
<tr>
<td>Obesity</td>
<td>11 326</td>
<td>15 538</td>
<td>0.7 (0.1)</td>
</tr>
<tr>
<td>Hemoglobinopathies</td>
<td>10 934</td>
<td>17 810</td>
<td>0.8 (0.1)</td>
</tr>
<tr>
<td>Liver disease</td>
<td>8984</td>
<td>10 897</td>
<td>0.5 (0.1)</td>
</tr>
<tr>
<td>Metabolic diseases</td>
<td>6844</td>
<td>9127</td>
<td>0.4 (0.1)</td>
</tr>
<tr>
<td>None of the above</td>
<td>303 857</td>
<td>294 079</td>
<td>12.7 (0.7)</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.
*Data are based on National Hospital Discharge Survey estimates for the United States.
†A hospitalization may be included in more than 1 diagnostic category.
‡The overall change in proportion of total is 19% (95% CI, 14%-24%).
§The estimates are considered unreliable for diagnostic categories with fewer than 10,000 hospitalizations.
Chronic Pulmonary Disease increased from 46.9% to 55.8%, which was a 19% increase (95% CI, 17%-21%); chronic pulmonary disease increased from 18.2% to 24.7%, a 36% increase (95% CI, 30%-41%); and diabetes increased from 15.8% to 20.8%, a 32% increase (95% CI, 28%-36%). From 1988-1990 to 2000-2002, the median number of first-listed and any-listed discharge diagnoses for pneumonia both increased from 5 to 7 while hospitalizations for all causes among patients aged 65 years or older increased from 4 to 6 diagnoses (P<.001), respectively.

Among patients who were hospitalized with pneumonia during 2000-2002, of those aged 65 to 74 years, 77% had chronic heart disease, chronic pulmonary disease, or diabetes mellitus as comorbid diagnoses; of those aged 75 to 84 years, 78% had at least 1 of 3 comorbid diagnoses; and of those aged 85 years or older, 76% had at least 1 of 3 comorbid diagnoses. However, the proportion of hospitalizations listing each underlying disease varied by age group: among those with pneumonia listed as the first discharge diagnosis, patients aged 65 to 74 years and aged 75 to 84 years were more likely to have chronic pulmonary disease or diabetes than those aged 85 years or older (FIGURE 2). Diabetes mellitus as a comorbid diagnosis increased by a relative 80% from 1988-2000 to 2000-2002 for patients aged 65 to 74 years compared with relative increases of 46% for patients aged 75 to 84 years and 30% for patients aged 85 years or older. Chronic pulmonary disease increased similarly in all age groups (32% for patients aged 65-74 years; 40% for patients aged 75-84 years; and 42% for patients aged ≥85 years).

From 1988 through 2002, an estimated 9.4 million (SE, 279 600) deaths occurred during hospitalization among patients aged 65 years or older. Of these deaths, 10% occurred during a hospitalization with pneumonia as the first-listed diagnosis and 22% during a hospitalization with pneumonia as any-listed diagnosis. Hospital mortality ratios were higher for patients with pneumonia as the first-listed or any-listed diagnosis and for patients with the other 10 most common causes of hospitalization (excluding pneumonia) during 1988-1990 compared with 2000-2002. However, the risk of dying in the hospital was 1.5 times greater for pneumonia hospitalizations compared with that for the other 10 most common causes of hospitalization during both 1988-1990 and 2000-2002 (TABLE 3).
COMMENT

Our results illustrate the large and increasing US burden of pneumonia among patients aged 65 years or older and suggest that an increase in chronic underlying conditions may contribute to increasing hospitalization rates. Hospitalizations with a first-listed or any-listed diagnosis of pneumonia increased by approximately 20% during the 15-year study period for patients aged 65 to 74 years and aged 75 to 84 years. During 2000-2002, approximately 1 in 83 patients aged 65 to 74 years and 1 in 38 patients aged 74 to 84 years were hospitalized each year with a first-listed diagnosis of pneumonia. Among adults aged 85 years or older, the rates of hospitalization for pneumonia did not change significantly over time but were consistently high, at least twice that of individuals aged 75 to 84 years. Because the rate of all-cause hospitalizations for older adults did not change during the study period, it is unlikely that changes in hospitalization practices fully account for the increase in pneumonia hospitalization rates. Concurrently, the proportion of hospitalized older adults with chronic cardiac disease, chronic pulmonary disease, or diabetes mellitus, in addition to pneumonia, increased by 17% from 66% during 1988-1990 to approximately 80% during 2000-2002. The increasing proportion of patients with underlying comorbid conditions among those hospitalized for pneumonia supports our primary hypothesis that an increase in the prevalence of underlying conditions that predispose individuals to pneumonia might partially account for the increase in rates of pneumonia hospitalization among patients aged 65 to 84 years. Our findings suggest that efforts to prevent pneumonia among older adults should focus on those at the extremes of age and those with underlying medical conditions.

Additional studies suggest that the prevalence of chronic cardiac disease, chronic pulmonary disease, or diabetes mellitus is increasing among older adults. For example, the number of individuals aged 65 years or older who reported having multiple risk factors for coronary heart disease or reported diabetes mellitus to the Behavioral Risk Factor Surveillance system increased during 1991 to 1999. The prevalence of mild or moderate obstructive lung disease recorded during the Third National Health and Nutrition Examination Survey (NHANES III; 1988-1994) increased among patients aged 65 to 74 years. Also, by American Diabetes Association criteria, the prevalence of diabetes increased from 8.9% in 1976-1980 to 12.3% during 1988-1994 among patients aged 40 to 74 years. In contrast, hospitalization rates for cerebrovascular accidents remained constant among those aged 65 years or older in a large health maintenance organization during 1967-1985 and declined in Minnesota among patients aged 30 to 74 years during 1980-1990. The high rates of pneumonia hospitalization among patients aged 85 years or older in our study are similar to those reported by others: 1 in 20 individuals aged 85 years or older were hospitalized each year with a primary diagnosis of pneumonia and 1 in 12 individuals were hospitalized each year with any diagnosis of pneumonia during 2000-2002. Moreover, the mortality associated with pneumonia disproportionately affects older adults, particularly those aged 85 years or older. In our study, the in-hospital fatality ratio for all patients aged 65 years or older was approximately 1.5-fold higher for hospitalizations with pneumonia as the first-listed diagnosis compared with that for the other most common causes of hospitalization among older adults. Patients aged 85 years or older had the highest in-hospital fatality ratios and...
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The number of hospitalizations for pneumonia increased significantly for individuals aged 65 to 74 years and aged 75 to 84 years but not for individuals aged 85 years or older; however, the proportions of individuals hospitalized for pneumonia with a comorbid condition increased among all age groups. The risk of hospitalization for pneumonia associated with advanced age may be greater than the risk associated with comorbidities. This point is supported by the study by Jackson et al.,4 which reported that the highest independent adjusted hazard ratio of hospitalization was for community-acquired pneumonia among individuals aged 85 years or older, exceeding the hazard ratios of hospitalization for patients with diabetes, congestive heart failure, and chronic obstructive pulmonary disease, and for individuals aged 75 to 84 years. Thus, it is possible that the increased prevalence of comorbidities has increased rates of pneumonia hospitalization among the younger age groups but not among individuals at the highest risk of hospitalization for pneumonia. Efforts to reduce preventable comorbid conditions may have the greatest impact on pneumonia hospitalization among individuals aged 65 to 84 years.

The average age of US residents in general, and among older adults in particular, is increasing.3 By 2010, an estimated 39 million US residents will be aged 65 years or older and by 2030 the total may reach 69 million.34 Individuals aged 85 years or older are the fastest growing age group in the United States and their number will double by 2025.34 In our study, the number of hospitalizations with pneumonia as the first-listed diagnosis increased from approximately 1.5 million during 1988-1990 to 2.3 million during 2000-2002 among individuals aged 65 years or older. If rates of pneumonia hospitalizations remain high or continue to increase, they will have a substantial impact on future health care needs.

Our study has several limitations. The increase in comorbid diagnoses reported from 1988-1990 to 2000-2002 could represent an artifact of better documentation to seek increased reimbursement for care covered by Medicare. Indeed, the median number of ICD-9-CM codes reported for each hospitalization increased from 1988-1990 to 2000-2002. However, not all comorbid diagnoses were more frequent in 2000-2002 compared with 1988-1990. For example, neuro/musculoskeletal codes remained stable or decreased for hospitalizations with pneumonia as the first-listed diagnosis and other evidence suggests that comorbid illnesses are increasing.23-28 Age and comorbidities have been identified as predictors of mortality due to pneumonia29 and may have influenced decisions to hospitalize individuals during 2000-2002. However, comorbid diagnoses of chronic cardiac disease, chronic pulmonary disease, and diabetes mellitus also increased among hospitalizations for all causes during the study period. The NHDS does not include data from Veterans Affairs medical centers and therefore we likely underestimated the number of hospitalizations for older adults in the United States. Also, one quarter of individuals admitted to the hospital for pneumonia were discharged to long-term care facilities where they may have subsequently died. Therefore, it is likely that we underestimated the number of deaths ultimately associated with pneumonia hospitalizations. Diagnoses were not clinically verified in the NHDS data collection process. Therefore, we do not have estimates of the impact of misclassification or misdiagnosis on our results. Finally, the proportion of individuals aged 65 years or older reporting receipt of annual influenza vaccine has increased from 30.4% in 1989 to 65.6% in 2002.30 However, the NHDS does not collect vaccination data. Without individual-level data concerning influenza vaccination status, it is not possible to estimate the effect of influenza vaccination on hospitalization trends for pneumonia during the study period.37

Additional factors may be influencing trends and, if so, will affect prevention strategies. Environmental factors such as exposure to tobacco smoke and air pollutants affect the acquisition and exacerbation of certain comorbid conditions and may affect the risk of hospitalization for pneumonia.4,36-41 Also, we were unable to examine the NHDS data by race/ethnicity and we did not have access to ZIP codes, educational status, functional status, or insurance status to explore social, socioeconomic, or access to care factors among the 3 age groups.

As the population of older adults and the prevalence of underlying medical conditions that predispose to pneumonia increase, hospitalizations for pneumonia are likely to continue to increase unless effective intervention strategies are implemented. Current US strategies to prevent pneumonia among older adults include recommending immunization with pneumococcal polysaccharide vaccine and annual influenza vaccinations.32,43 However, the effectiveness of these vaccines decreases with increasing age and among individuals with comorbid conditions,29,44-51 a population increasingly accounting for pneumonia hospitalizations. Our results suggest that efforts to reduce preventable comorbid conditions may slow current trends in pneumonia hospitalizations, especially for individuals aged 65 to 84 years. Studies to evaluate the effect of interventions to reduce preventable comorbid conditions on pneumonia hospitalizations are needed. However, because the number of individuals at highest risk for pneumonia, those aged 85 years or older, will continue to increase in the United States and behavioral changes may be difficult to sustain, additional strategies, such as more effective vaccines for older individuals and new vaccines for common pathogens without a currently licensed vaccine, eg, respiratory syncytial virus,62 will likely be necessary.

In conclusion, our results demonstrate the large and increasing national burden of pneumonia among individuals aged 65 to 74 years and aged
75 to 84 years and suggest that an increase in chronic underlying conditions contributed to increasing hospitalization rates. Although the rates of hospitalization for pneumonia among adults aged 85 years or older did not change significantly over time, this age group had consistently high rates of hospitalization and increasing numbers of pneumonia hospitalizations during the study period. Our findings suggest that efforts to prevent pneumonia should be directed at reducing preventable comorbid conditions and improving vaccine effectiveness and vaccination programs in elderly persons.

Author Contributions: Dr Fry had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Fry, Shay, Holman, Anderson.

Acquisition of data: Holman, Cums. Analysis and interpretation of data: Fry, Shay, Holman, Anderson.

Drafting of the manuscript: Fry, Shay.

Critical revision of the manuscript for important intellectual content: Shay, Holman, Cums, Anderson.

Statistical analysis: Fry, Holman, Cums. Administrative, technical, or material support: Fry, Holman, Cums, Anderson.

Study supervision: Anderson.

Financial Disclosures: None reported.

Acknowledgment: We thank Maria F. Owings, PhD (Hospital Care Statistics Branch, Division of Health Care Cost and Utilization, National Center for Health Statistics, Cen-

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