Quality of Care for Elderly Patients Hospitalized for Pneumonia in the United States, 2006 to 2010

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IMPORTANCE Nearly every US acute care hospital reports publicly on adherence to recommended processes of care for patients hospitalized with pneumonia. However, it remains uncertain how much performance of these process measures has improved over time or whether performance is associated with superior patient outcomes.

OBJECTIVES To describe trends in processes of care, mortality, and readmission for elderly patients hospitalized for pneumonia and to assess the independent associations between processes and outcomes of care.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study conducted from January 1, 2006, to December 31, 2010, at 4740 US acute care hospitals. The cohort included 1818 979 cases of pneumonia in elderly (≥65 years), Medicare fee-for-service patients who were eligible for at least 1 of 7 pneumonia inpatient processes of care tracked by the Centers for Medicare & Medicaid Services (CMS).

MAIN OUTCOMES AND MEASURES Annual performance rates for 7 pneumonia processes of care and an all-or-none composite of these measures; and 30-day, all-cause mortality and hospital readmission, adjusted for patient and hospital characteristics.

RESULTS Adjusted annual performance rates for all 7 CMS processes of care (expressed in percentage points per year) increased significantly from 2006 to 2010, ranging from 1.02 for antibiotic initiation within 6 hours to 5.30 for influenza vaccination (P < .001). All 7 measures were performed in more than 92% of eligible cases in 2010. The all-or-none composite demonstrated the largest adjusted relative increase over time (6.87 percentage points per year; P < .001) and was achieved in 87.4% of cases in 2010. Adjusted annual mortality decreased by 0.09 percentage points per year (P < .001), driven primarily by decreasing mortality in the subgroup not treated in the intensive care unit (ICU) (−0.18 percentage points per year; P < .001). Adjusted annual readmission rates decreased significantly by 0.25 percentage points per year (P < .001). All 7 processes of care were independently associated with reduced 30-day mortality, and 5 were associated with reduced 30-day readmission.

CONCLUSIONS AND RELEVANCE Performance of processes of care for elderly patients hospitalized for pneumonia improved substantially from 2006 to 2010. Adjusted 30-day mortality declined slightly over time primarily owing to improved survival among non-ICU patients, and all individual processes of care were independently associated with reduced mortality.
Over the past 2 decades, national efforts to improve the quality of care for pneumonia have focused on processes of care. In 2003, the Centers for Medicare & Medicaid Services (CMS) implemented the Hospital Inpatient Quality Reporting (IQR) Program, requiring all general, acute care hospitals to submit process measure performance data for pneumonia and other conditions to be eligible for their annual Medicare reimbursement update. Working in conjunction with the CMS, the Joint Commission (TJC) uses performance on the same process measures in its national hospital accreditation program. Performance data for individual hospitals are publicly reported on the CMS Hospital Compare and TJC Quality Check websites and are used in CMS hospital pay-for-performance programs.

Although prior studies documented improvements in the performance of pneumonia processes of care over time, these investigations were performed using data from 1998 to 2005, before the full impact of the IQR program could be adequately assessed. During that period, performance rates remained lower than 90% for all pneumonia process measures. Two studies using data from 1987 to 2009 demonstrated that severity-adjusted, short-term mortality following pneumonia decreased, but neither assessed the influence of processes of care on patient outcomes. Some observational studies have demonstrated associations between performance of blood cultures, rapid initiation and appropriate selection of antibiotic therapy, and pneumococcal and influenza vaccinations and decreased short-term mortality for patients hospitalized for pneumonia, but not all studies have demonstrated consistent results. Few recent studies have evaluated the associations between processes of care and 30-day readmission, an outcome systematically tracked by CMS.

To better understand the longitudinal impact of the ongoing CMS and TJC quality improvement initiatives for pneumonia, we examined (1) national trends in the performance of processes of care and patient outcomes and (2) the associations between processes of care and patient outcomes in a national cohort of elderly patients hospitalized for pneumonia.

Methods

Study Design

We performed a retrospective cohort study of cases of pneumonia requiring hospitalization submitted to the national Quality Improvement Organization (QIO) Clinical Data Warehouse (CDW) by hospitals participating in the IQR Program. This warehouse stores patient-level process of care data for quality improvement and public reporting purposes and undergoes random validation audits by an independent CMS contractor. Reporting hospitals must submit all cases of pneumonia meeting International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) criteria or a random sample depending on case volume. Although the IQR Program is voluntary, participation is tied to financial reimbursement, and approximately 99% of eligible hospitals participate in the program. The submitted cases represent a nearly complete census of pneumonia hospitalizations in adults (≥18 years) to all US nonfederal, acute care hospitals, including all city and state hospitals that bill Medicare and excluding Veterans Affairs and Department of Defense hospitals. We linked the CDW data to individual patient outcomes using CMS administrative data. Institutional review board approval was not required because all data were collected for the Medicare IQR Program.

Patient Selection

We included fee-for-service (FFS) Medicare patients 65 years or older who were hospitalized for pneumonia from January 1, 2006, through December 31, 2010. From an initial population of all adult (≥18 years) cases of pneumonia in the CDW, we sequentially excluded patients who were (1) ineligible for all 7 pneumonia processes of care, (2) younger than 65 years, and (3) for whom specified 30-day outcomes could not be assessed owing to missing or unverifiable health insurance claims. Cases of pneumonia were identified using established ICD-9-CM diagnosis codes and were confirmed radiographically by medical record reviews conducted by hospital personnel using uniform IQR Program specifications. All cases had an ICD-9-CM principal diagnosis code for pneumonia or a principal diagnosis code for septicemia or respiratory failure accompanied by another diagnosis code for pneumonia (eTable 1 in the Supplement). Patients without abnormal radiographic findings during hospitalization were excluded beginning July 2006. For all study years, patients with cystic fibrosis, hospital stays exceeding 120 days, or participation in clinical trials were excluded.

Patient and Hospital Characteristics

We abstracted patient and hospital characteristics using data from the US Census Bureau, the American Hospital Association, the CDW, and other CMS databases. We identified patient demographics (age and sex), admission characteristics (emergency department presentation and admission or transfer to an intensive care unit [ICU] within 24 hours of hospital admission), and 29 comorbid conditions defined by Elixhauser et al. To account for the possibility of differential treatment by race and/or ethnicity, we defined a combined variable (white, non-Hispanic; black, non-Hispanic; Hispanic; and other or unknown race/ethnicity) using medical chart-abstracted data captured for the CDW. We defined poverty status and educational attainment based on patients’ zip codes using US Census Bureau data and definitions. We identified patients with health care-associated pneumonia (HCAP) through medical record review defined by the presence of at least 1 of the following criteria: acute care hospitalization within 90 days; residence in a nursing home or extended care facility within 90 days; chronic dialysis within 30 days; or wound, tracheostomy, or ventilator care within 30 days of admission. We assessed hospital characteristics, including urban vs rural location, geographic region, teaching status, bed size, and annual volumes of all Medicare FFS inpatient claims and pneumonia cases submitted to the CDW.

Processes of Care

We studied the 7 processes of care recommended by CMS for calendar years 2006 through 2010 for patients hospitalized for...
pneumonia. All processes of care were evaluated in unique patient subgroups defined and updated by CMS (eTable 2 in the Supplement). During the study time frame, only minor changes were made to these eligibility criteria.28 With the exception of time to initiate antibiotic therapy, we used CMS process measure definitions in place at the time of patient hospitalization to assess annual performance rates for all measures. For time to initiate antibiotic therapy, we retroactively applied a 6-hour time limit from hospital arrival to administration of the first antibiotic therapy, we used CMS process measure definitions in place at the time of patient hospitalization to assess annual performance rates for all measures.

### Patient Outcomes

Our primary outcomes were all-cause mortality within 30 days of admission and all-cause readmission within 30 days of discharge. We analyzed outcomes for all inpatients and separately for ICU and non-ICU inpatients.

### Statistical Analyses

We used the Cochran-Armitage χ² test for trend and linear regression analyses to evaluate time trends for patient and hospital characteristics and for unadjusted medical outcomes. We used multivariable logistic regression to calculate adjusted annual medical outcomes and multivariable linear regression to estimate adjusted time trends (ie, slopes in percentage points per year) in performance of processes of care and medical outcomes.

We used similar multivariable models to assess the independent associations between all individual processes of care and the 2 study outcomes for each year and for the entire 5-year study period. All multivariable models included all patient and hospital characteristics, described herein. We did not assess associations between the all-or-none measure and our study outcomes because variations in patient eligibility criteria for the individual measures and exclusion of patient deaths from the preventive measures could potentially bias the quantification of these associations.

We performed all statistical analyses using SAS software (version 9.2; SAS Institute Inc) and Elixhauser comorbidity software.32 We used 2-sided statistical tests and a P < .01 to define statistical significance.

### Results

#### Patient and Hospital Characteristics

From a national sample of 5 412 117 adult pneumonia cases, we analyzed 1 818 979 cases in hospitalized, elderly, Medicare FFS patients (eFigure in the Supplement). Overall, 1 477 248 of the eligible cases (81.2%) represented unique patients. Compared with our study population, elderly patients with pneumonia excluded because of inadequate data to assess 30-day outcomes were similar in age, sex, and poverty status and had nearly identical in-hospital mortality (data not shown).

Patients represented by all cases had a mean (SD) age of 79.7 (8.2) years, 54.0% were female, and 83.6% were non-Hispanic white (Table 1). In time-trend analyses, larger proportions of cases met criteria for HCAP (35.3% to 41.3%; P < .001) and were admitted to an ICU (12.1% to 14.4%; P < .001). The average number of comorbid conditions per case also increased from 3.4 to 3.9 (P < .001).

Cases in the study sample were reported from 4740 unique hospitals, of which 54.9% were urban, 66.9% were located in the South or Midwest, and 72.8% were small to medium in bed size and nonteaching. At the annual per-hospital level, the median volume of pneumonia cases ranged from 193 to 203. No hospital characteristics varied significantly over time (data not shown).

#### Processes of Care Over Time

Adjusted annual performance rates for all 7 CMS processes of care (expressed in percentage points per year) increased significantly (P < .001) from 2006 to 2010, ranging from 1.02 to 5.30 for antibiotic initiation within 6 hours to 5.30 for influenza vaccination (Table 2). With the exception of appropriate antibiotic therapy among the subgroup of ICU patients (performance rate, 76.5%), all measures were performed in more than 92% of eligible cases in 2010. The all-or-none composite demonstrated the largest adjusted relative increase over time (6.87 percentage points per year; P < .001) and was achieved in 87.4% of cases in 2010 (Table 2 and Figure). The characteristics of patients who received or did not receive all processes of care are shown in eTable 3 in the Supplement.

#### Outcomes Over Time

In all cases, 30-day mortality was 10.4% (range, 9.2%-11.4% per year) and readmission within 30 days was 20.4% (range, 19.5%-20.7% per year) (Table 3). Annual mortality for the ICU subgroup was more than 2-fold higher than for the non-ICU subgroup (range, 19.9%-25.6% vs 7.6%-9.2%), and readmission rates were 5.4 to 6.2 percentage points higher in the ICU subgroup across all study years (range, 25.0%-26.2% vs 18.8%-20.0%).

Adjusted annual mortality decreased significantly (P < .001) by 0.09 percentage points per year from 2006 to 2010 (Table 3 and Figure), driven primarily by a decreasing adjusted annual mortality of 0.18 percentage points per year (P < .001) in the non-ICU subgroup. In contrast, the ICU subgroup had an increasing adjusted annual mortality (0.42 percentage points per year; P < .001). Adjusted annual readmission rates decreased significantly by 0.25 percentage points per year for all cases (P < .001), with similar decreases in the ICU and non-ICU subgroups.
Associations Between Processes and Outcomes

Among all patients eligible for a given process of care over the 5-year study, unadjusted 30-day mortality was significantly lower \((P < .001)\) for those who received (vs did not receive) appropriate antibiotic therapy (5.7% vs 10.4%), blood cultures in the emergency department (12.3% vs 13.0%), smoking cessation counseling (3.9% vs 6.4%), and pneumococcal (4.8% vs 6.4%) and influenza vaccination (5.0% vs 6.7%) (Table 4). In multivariable analyses, all processes of care were independently associated with reduced 30-day mortality; reductions were greatest for appropriate antibiotic therapy (adjusted odds ratio [AOR], 0.79 [95% CI, 0.77-0.82]), pneumococcal (AOR, 0.80 [95% CI, 0.78-0.82]) and influenza (AOR, 0.78 [95% CI, 0.76-0.80]) vaccinations, and smoking cessation counseling (AOR, 0.74 [95% CI, 0.68-0.80]).

Unadjusted 30-day readmission rates were significantly lower \((P < .001)\) for those who received antibiotic therapy within 6 hours (19.0% vs 20.5%), appropriate antibiotic therapy (14.5% vs 17.8%), smoking cessation counseling (21.3% vs 24.2%), and influenza vaccination (20.6% vs 21.7%). In multivariable analyses, these 4 process measures and blood cultures performed in
Table 2. Performance Rates of Processes of Care for Elderly* FFS Medicare Patients Hospitalized for Pneumonia, January 1, 2006, to December 31, 2010

<table>
<thead>
<tr>
<th>Processes of Care</th>
<th>2006Cases per Year, No. (%)</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Slope^e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic therapy Initiation ≤6 h</td>
<td>251 171 (91.9)</td>
<td>230 427 (93.8)</td>
<td>243 569 (94.2)</td>
<td>219 247 (95.3)</td>
<td>225 608 (96.2)</td>
<td>1.02</td>
</tr>
<tr>
<td>Appropriate selection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>163 829 (85.3)</td>
<td>142 027 (88.5)</td>
<td>147 025 (88.9)</td>
<td>126 086 (91.0)</td>
<td>128 380 (92.8)</td>
<td>1.76</td>
</tr>
<tr>
<td>Non-ICU patients^d</td>
<td>147 563 (88.1)</td>
<td>129 147 (91.0)</td>
<td>133 058 (92.0)</td>
<td>113 442 (93.8)</td>
<td>115 948 (94.5)</td>
<td>1.57</td>
</tr>
<tr>
<td>ICU patients^c</td>
<td>16 266 (59.7)</td>
<td>12 880 (63.5)</td>
<td>13 967 (59.2)</td>
<td>12 644 (66.7)</td>
<td>12 412 (76.5)</td>
<td>3.55</td>
</tr>
<tr>
<td>Performance of blood cultures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 24 h for ICU patients</td>
<td>38 373 (89.7)</td>
<td>36 134 (91.9)</td>
<td>43 532 (93.3)</td>
<td>41 303 (95.3)</td>
<td>44 487 (96.4)</td>
<td>1.72</td>
</tr>
<tr>
<td>Before antibiotic therapy in ED</td>
<td>217 514 (91.1)</td>
<td>206 302 (91.9)</td>
<td>226 009 (93.9)</td>
<td>199 632 (95.7)</td>
<td>213 827 (96.8)</td>
<td>1.54</td>
</tr>
<tr>
<td>Prevention measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking cessation counseling</td>
<td>39 950 (86.3)</td>
<td>44 987 (91.0)</td>
<td>46 717 (93.8)</td>
<td>41 672 (96.2)</td>
<td>42 680 (97.3)</td>
<td>2.85</td>
</tr>
<tr>
<td>Pneumococcal vaccination</td>
<td>300 903 (75.5)</td>
<td>347 923 (83.5)</td>
<td>367 003 (88.6)</td>
<td>320 484 (92.7)</td>
<td>334 020 (94.6)</td>
<td>4.73</td>
</tr>
<tr>
<td>Influenza vaccination</td>
<td>140 860 (71.6)</td>
<td>148 088 (81.2)</td>
<td>148 088 (81.2)</td>
<td>148 088 (81.2)</td>
<td>148 088 (81.2)</td>
<td>5.30</td>
</tr>
<tr>
<td>All-or-none measure^e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>326 956 (58.9)</td>
<td>369 042 (70.9)</td>
<td>399 243 (77.4)</td>
<td>354 137 (84.0)</td>
<td>369 601 (87.4)</td>
<td>6.87</td>
</tr>
<tr>
<td>Non-ICU patients^d</td>
<td>287 273 (60.5)</td>
<td>327 676 (72.4)</td>
<td>348 672 (78.8)</td>
<td>305 145 (85.1)</td>
<td>316 339 (88.2)</td>
<td>6.60</td>
</tr>
<tr>
<td>ICU patients^c</td>
<td>39 683 (47.2)</td>
<td>41 366 (59.6)</td>
<td>50 571 (67.8)</td>
<td>48 992 (76.5)</td>
<td>53 262 (82.6)</td>
<td>8.33</td>
</tr>
</tbody>
</table>

Abbreviations: ED, emergency department; FFS, fee-for-service; ICU, intensive care unit.
* Age 65 years or older.
^a The 7 CMS pneumonia processes of care are antibiotic initiation within 6 hours, appropriate antibiotic selection (all patients), performance of blood cultures within 24 hours for ICU patients, performance of blood cultures before antibiotic therapy in the ED, smoking cessation counseling, and pneumococcal and influenza vaccination. The number represents the annual number of pneumonia cases eligible for each process of care.
^b Percentage points per year.
^c All patients are those who received all processes of care.
^d ICU patients are individuals who were admitted or transferred to the ICU within 24 hours of hospital admission. Non-ICU patients are all other individuals not meeting these criteria.
^e The all-or-none composite measure is met for patients who receive all processes of care for which they were eligible.

Discussion

In this 5-year study of more than 1.8 million cases of pneumonia in elderly patients treated in US hospitals, we demonstrated substantial improvements in health care quality based on both processes and outcomes of care. From 2006 to 2010, performance rates increased for all 7 CMS pneumonia processes of care, with the most recent rates exceeding 92% for all measures. All pneumonia processes of care were independently associated with lower mortality, and 5 were independently associated with lower readmission rates. Over the same time frame, we observed small, albeit statistically significant, reductions in 30-day mortality and readmission despite evidence that comorbidity, prevalence of HCAP, and requirement for ICU admission increased over time.

Consistent with findings of prior work, we found improvements over time in performance of all inpatient processes of care for pneumonia.9,11,12 Our more contemporary analyses demonstrate higher levels of performance (93% to 97% in 2010) for all CMS processes of care. Achievement of universally high performance levels for these process measures over the past 2 decades is likely due to multiple factors, including the National Pneumonia Project launched by the CMS in 1999, the near-universal tracking and public reporting of hospital per-

the emergency department were independently associated with lower odds of readmission. Year-by-year analyses of process-outcome associations demonstrated findings consistent with the combined 5-year results for both mortality and readmission (eTable 4 in the Supplement).
In parallel with improvements in processes of care, we found a small yet statistically significant decrease in severity-adjusted pneumonia mortality over time. Our estimated reduction in adjusted mortality of 0.09 percentage points per year (2006-2010) is consistent with the similarly adjusted 0.07 annual percentage point reduction (2003-2009) reported in a recent national study of all adults hospitalized for pneumonia. Consistent with prior studies examining temporal trends in pneumonia mortality, we adjusted for an increasing burden of comorbid illness; however, we also adjusted for increasing rates of HCAP and ICU admission over time. Finally, we demonstrated that the declining overall mortality for pneumonia in elderly patients is largely due to improved survival in patients who are treated in a non-ICU setting.

In our assessments of process-outcomes associations, we found that all 7 CMS pneumonia processes of care were independently associated with relative reductions in the odds of death within 30 days of admission of 5% or more and the magnitude of these associations was consistent over time. Antibiotic timing and selection, blood cultures performed in the emergency department, smoking cessation counseling, and influenza vaccination were also independently associated with a lower likelihood of hospital readmission. Since 30-day mortality and readmission are performance metrics guiding future, value-based CMS reimbursements to hospitals for conditions including pneumonia, it is essential for clinicians, hospital, and payer stakeholders to understand how performance of individual processes of care is associated with these medical outcomes.

In our study, the adjusted odds of 30-day mortality for patients who received appropriate antibiotic therapy were reduced by 21%, with larger relative reductions in the non-ICU than in the ICU setting (25% vs 15%). The magnitude of these associations is consistent with findings from 2 older studies, demonstrating that antibiotic therapy providing coverage for typical and atypical bacterial pathogens was associated with relative mortality reductions of 26% to 76%. More recent meta-analyses focusing on the role of macrolides in ICU and non-ICU settings have also demonstrated the importance of guideline-concordant antibiotic therapy in patients hospitalized for...
screening for vaccination status followed by pneumococcal and influenza vaccination, if indicated, was associated with 22% and 25% relative reductions in the odds of death for these respective vaccines. Prior observational studies examining the impact of these vaccinations before hospitalization for pneumonia demonstrated even larger effects, with relative mortality reductions of 35% to 50%. However, more recent meta-analyses examining pneumococcal vaccination efficacy in all eligible adults failed to show an association with decreased all-cause mortality. In addition, a Cochrane review of influenza vaccination in elderly patients raised concerns that systematic biases, such as frailty bias, could be driving associations with reduced mortality in observational studies such as ours.

Unexpectedly, we found large reductions in mortality and readmission rates associated with smoking cessation counseling, a potentially important finding given that an estimated 9% of elderly individuals in the United States smoked in 2010. Although it is not clear what proportion of counseled smokers actually stopped smoking, prior studies of patients hospitalized for acute myocardial infarction also demonstrated improved 30-day survival for counseled patients. The mechanisms underlying this mortality benefit are unclear but may stem from reductions in actual smoking behavior, as inpatient smoking cessation interventions during admission for acute medical conditions substantially increase short-term smoking cessation rates. Alternatively, this association could reflect the effects of unaddressed confounding by factors contributing to a decreased likelihood of counseling and worse health outcomes, such as a history of poor compliance with medical therapies, psychiatric illness, or frailty.

Our findings have important implications for the future direction of national pneumonia quality improvement programs. First, systematically tracking and publicly reporting performance rates for processes of care and using these data to incentivize facilities to improve health care delivery likely contributed to improved performance rates and should remain a component of such programs. Second, the strong associations between select process measures (eg, appropriate antibiotic selection, and influenza and pneumococcal vaccination) and medical outcomes should prioritize these particular measures for future efforts to improve outcomes of hospitalized patients with pneumonia. Third, with the recent retirement of multiple measures that have reached ceiling performance rates, it will be essential to develop ongoing surveillance methods to ensure that performance does not regress over time. Finally, as process measures are deprioritized after more than 2 decades of focused use, medical outcomes should take

Table 4. Associations Between Processes of Care and Medical Outcomes for Elderly FFS Medicare Patients Hospitalized for Pneumonia, January 1, 2006, to December 31, 2010

<table>
<thead>
<tr>
<th>Processes of Care</th>
<th>Outcome: 30-Day Mortality</th>
<th>Outcome: 30-Day Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process Recd, % of Eligible Cases</td>
<td>Process Not Recd, % of Eligible Cases</td>
</tr>
<tr>
<td>Antibiotic therapy</td>
<td>Initiation ≤6 h</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td>Appropriate selection</td>
<td></td>
</tr>
<tr>
<td>All patients</td>
<td>5.7</td>
<td>10.4</td>
</tr>
<tr>
<td>Non-ICU patients</td>
<td>4.9</td>
<td>6.5</td>
</tr>
<tr>
<td>ICU patients</td>
<td>17.1</td>
<td>19.1</td>
</tr>
<tr>
<td>Performance of blood cultures</td>
<td>Within 24 h for ICU patients</td>
<td>25.4</td>
</tr>
<tr>
<td>Before antibiotic therapy in ED</td>
<td>12.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Prevention measures</td>
<td>Smoking cessation counseling</td>
<td>3.9</td>
</tr>
<tr>
<td>Pneumococcal vaccination</td>
<td>4.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Influenza vaccination</td>
<td>5.0</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Abbreviations: AOR, adjusted odds ratio; ED, emergency department; FFS, fee-for-service; ICU, intensive care unit; OR, odds ratio; recd, received.

a Age 65 years or older.
b Odds ratios represent the unadjusted odds of mortality or hospital readmission within 30 days for all cases in the 5-year study sample eligible for a given process of care, comparing those who received vs did not receive a given process measure.
c Adjusted odds ratios were calculated using multivariable logistic regression, adjusting for patient and hospital characteristics.
d ICU patients are individuals who were admitted or transferred to the ICU within 24 hours of hospital admission. Non-ICU patients are all other individuals not meeting these criteria.

pneumonia. Appropriate antibiotic therapy was also associated with 9% to 16% relative reductions in the odds of readmission (ICU and non-ICU settings, respectively), further validating the importance of this process measure.

We found that screening for vaccination status followed by pneumococcal and influenza vaccination, if indicated, was associated with 22% and 25% relative reductions in the odds of death for these respective vaccines. Prior observational studies examining the impact of these vaccinations before hospitalization for pneumonia demonstrated even larger effects, with relative mortality reductions of 35% to 50%. However, more recent meta-analyses examining pneumococcal vaccination efficacy in all eligible adults failed to show an association with decreased all-cause mortality. In addition, a Cochrane review of influenza vaccination in elderly patients raised concerns that systematic biases, such as frailty bias, could be driving associations with reduced mortality in observational studies such as ours.

Unexpectedly, we found large reductions in mortality and readmission rates associated with smoking cessation counseling, a potentially important finding given that an estimated 9% of elderly individuals in the United States smoked in 2010. Although it is not clear what proportion of counseled smokers actually stopped smoking, prior studies of patients hospitalized for acute myocardial infarction also demonstrated improved 30-day survival for counseled patients. The mechanisms underlying this mortality benefit are unclear but may stem from reductions in actual smoking behavior, as inpatient smoking cessation interventions during admission for acute medical conditions substantially increase short-term smoking cessation rates. Alternatively, this association could reflect the effects of unaddressed confounding by factors contributing to a decreased likelihood of counseling and worse health outcomes, such as a history of poor compliance with medical therapies, psychiatric illness, or frailty.
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Original Investigation Research

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outcomes associations were affected by frailty bias, which is
difficult to circumvent in studies that rely on administrative
data.46-49 Finally, our nonclustered multivariable analyses
did not quantify the magnitude of effect of the site of hospi-
talization on the observed process-outcomes associations.
Thus, it is possible that hospitals where recommended pro-
cesses of care were performed at the highest rates also had
the lowest patient mortality and readmission rates owing to
confounding by unmeasured hospital quality of care.

Conclusions

Our study demonstrates that quality of care for elderly pa-
hospitalized for pneumonia in the United States has im-
proved from 2006 to 2010 with all recommended processes of
care performed in over 90% of eligible patients. While selec-
tive use of processes of care and ongoing process measure sur-
veillance are warranted, future efforts to improve the quality
of care for pneumonia should increasingly rely on patient-
centered medical outcomes as quality metrics.

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Critical revision of the manuscript for important intellectual content: All authors.
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Administrative, technical, or material support: Lee,
Bratziel, Baus, Labri.
Study supervision: Lee, Baus, Labri, Fine.

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and Ms Auden reported being employees of the
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