Mortality Reduction among Pneumonia Patients Still Substantial despite the Impact of Coding Changes

Gregory W. Ruhnke, MD, MS, MPH,a Marcelo Coca Perraillon, MA,b David M. Cutler, Phdc

aDepartment of Medicine and bDepartment of Health Studies, University of Chicago, Ill; cDepartment of Economics, Harvard University, Cambridge, Mass.

ABSTRACT

BACKGROUND: Accounting for changes in coding practices may be important in analyzing trends based on administrative data. Several studies have demonstrated large reductions in mortality over time among pneumonia patients. However, a recent study suggested that this reduction may have been an artifact of case definition because more of the highest-risk patients were being coded under alternative principal diagnoses in recent years.

METHODS: Using the National Inpatient Sample from 1993 to 2005, we selected hospitalizations with a principal diagnosis of pneumonia or a secondary diagnosis of pneumonia and a principal diagnosis of sepsis or respiratory failure. We performed logistic regression, estimating the likelihood of in-hospital mortality in each year, adjusting for age, sex, and comorbidities.

RESULTS: Over time, there was a substantial increase in the frequency of sepsis and respiratory failure as a principal diagnosis. Length of stay decreased in all 3 principal diagnosis groups. By 2005, the adjusted odds ratio (OR) of death among principal diagnosis pneumonia and respiratory failure hospitalizations decreased to 0.50 (95% confidence interval [CI], 0.49-0.51) and 0.62 (95% CI, 0.58-0.66), respectively, compared with 1993. With all 3 groups combined, there was still a substantial, albeit attenuated, reduction in the risk of mortality (OR2005 0.70; 95% CI, 0.69-0.72).

CONCLUSIONS: Survival of patients with community-acquired pneumonia has improved greatly over time. However, interpretation of such findings based on administrative data must be made with caution and careful attention to case definition and coding trends.

© 2013 Elsevier Inc. All rights reserved.

KEYWORDS: Administrative data; Case definition; Mortality; Pneumonia; Respiratory failure; Sepsis

Administrative claims data have well-known shortcomings,1 some of which may become pronounced in the analysis of trends. Over time, new codes are introduced, disease definitions change, new diagnostic tests become available, and coding systems are modified. Because such data will continue to be used for research, policy decisions, and performance metrics, continuously improving our understanding of how to use and interpret findings based on administrative data is critical. Several published reports using such data have demonstrated a reduction in both in-hospital and 30-day mortality among community-acquired pneumonia patients during various intervals from 1987 to 2005.2,4 However, a recent article by Lindenauer et al8 suggested that changes in coding practices may be responsible for this apparent reduction in mortality. Using the National Inpatient Sample, the authors showed a shift between 2003 and 2009 from a principal diagnosis of pneumonia toward principal diagnoses of sepsis and respiratory failure, with a secondary diagnosis of pneumonia among the highest-risk patients hospitalized for pneumonia. They concluded that such a shift had caused exclusion of the sickest patients during recent years in the prior studies, which did not include pneumonia patients with other principal diagnoses. Therefore they suggested that coding issues, rather than improvements in care, might be responsible for the large reduction in mortality reported among pneumonia
patients. However, most of the mortality reduction demonstrated in previous studies was before 2003. Therefore, we hypothesized that the discrepancy is based largely on the difference in the time frames analyzed.

**METHODS**

As in a prior study, we identified patients hospitalized for pneumonia using National Inpatient Sample data from 1993 to 2005. First, we selected patients with a principal diagnosis of pneumonia using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes 481-486. Using the same codes as Lindenauer et al., we then selected patients with a principal diagnosis of sepsis (ICD-9-CM codes 038, 995.91, 785.52) or respiratory failure (ICD-9-CM codes 518.81, 518.82, 518.84, 799.1) and a secondary diagnosis of pneumonia. Using the Elixhauser Comorbidity Software, comorbidity indicator variables were defined based on the discharge diagnoses. Multivariate logistic regression was then performed, estimating the likelihood of death. Our outcome measure was the adjusted odds ratio (OR) of in-hospital death in each year, relative to reference year 1993. The analyses regressed a mortality indicator on categorical variables for each year, sex, age by 10-year categories, and the 29 comorbidity indicators. We performed this regression for each of the 3 groups (principal-diagnosis pneumonia, principal-diagnosis sepsis, principal-diagnosis respiratory failure) separately, and then for a combined group.

**CLINICAL SIGNIFICANCE**

- Mortality trends among pneumonia patients analyzed with administrative data may be influenced by changes in coding practices over time.
- The highest-risk pneumonia patients may be more likely to receive a principal diagnosis of sepsis or respiratory failure in recent years.
- Mortality among pneumonia patients has reduced substantially over time. However, this reduction is attenuated to some extent when pneumonia patients who received alternative principal diagnoses are included.

**RESULTS**

The Table shows the characteristics of the study subjects from 2 periods. The mean length of stay decreased in all 3 groups, although less markedly in the principal-diagnosis sepsis group. Unadjusted mortality was reduced in the recent period among principal-diagnosis pneumonia and principal-diagnosis respiratory failure patients with relative risk reductions of 33.4% and 24.6%, respectively. Figure 1 demonstrates that several comorbidities became more common within all 3 principal-diagnosis groups. Figure 2 shows that, among principal-diagnosis pneumonia hospitalizations (overall mortality rate [OMR] 6.7%), adjusted for age, sex, and comorbid conditions, the odds ratio (OR) of death decreased with time to 0.50 (95% confidence interval [CI], 0.49-0.51) in 2005, relative to 1993. While the risk of mortality among principal-diagnosis respiratory failure hospitalizations also decreased (OMR 26.1%; OR<sub>2005</sub> 0.62; 95% CI, 0.58-0.66), there was little...
change in mortality among principal-diagnosis sepsis hospitalizations (OMR 24.2%; OR2005 0.97; 95% CI, 0.91-1.02). Figure 2 also shows that when these groups were combined, there was still a substantially reduced risk of mortality (OR2005 0.70; 95% CI, 0.69-0.72).

**DISCUSSION**

While inclusion of the alternative principal-diagnosis hospitalizations does diminish the mortality reduction over time that we originally demonstrated, there is still a substantial decrease. In our prior work, we had hypothesized that the mortality reduction observed from 1987 to 2005 was due mostly to increases in the rate of pneumococcal (from 12.7% to 65.9%) and influenza (from 28.0% to 65.7%) vaccinations among the elderly (which are associated with reduced mortality among patients who still get pneumonia), as well as greater use of guideline-concordant broad-spectrum antibiotics. From 1992 to 2004, the proportion of patients receiving such antibiotics (which are associated with a one-third reduction in mortality) increased from 54% to 88%. Although changes in discharge practices (reduced length of stay and more discharges to other facilities) might have shifted more deaths of hospitalized patients to postacute care settings over time, daily mortality risk and hazard model analyses showed that the mortality reduction was robust.

It is not surprising that Lindenauer et al found little change in mortality from 2003 to 2009, because there was no substantial increase in vaccination rates during this time. Also, no important change in antibiotic use among hospitalized pneumonia patients occurred in the last decade. At the same time, evidence-based decisions using the pneumonia severity index to determine site of care as well as greater use of highly bioavailable oral respiratory fluoroquinolones may have reduced admission rates among the lowest-risk pneumonia patients. Such a migration to the outpatient setting might have prevented Lindenauer et al from identifying the impact of improved care on the more severely ill patients still hospitalized in recent years. Survival of patients with community-acquired pneumonia has improved greatly since the 1980s.

However, inclusion of patients with a secondary diagnosis of pneumonia and the alternative principal diagnoses did significantly attenuate the previously observed mortality reduction. Studies that validate administrative diagnostic coding algorithms with clinical chart review are critical if these codes will be used to draw epidemiologic inferences, compare hospitals, or sample patients for performance measurement. One study demonstrated that limiting case definition to principal-diagnosis pneumonia patients lowered the observed mortality rate from 7.5% to 5.8% relative to the total set of cases defined by clinical chart review. This study showed that including patients with a secondary pneumonia diagnosis and a limited set of alternative principal diagnoses resulted in a mortality rate much closer to the set defined by the gold standard chart review. If coding prac-
Practices change over time due to modification in reimbursement policies, disease definitions, or other factors, repeat of such studies may be warranted. In the United Kingdom, the measurement and reporting of hospital standardized mortality ratios caused a large increase in the coding of palliative care, which excludes deaths from such calculations. Especially when the adoption of such changes in coding practices are not uniform across principal diagnoses or geographic regions, these behaviors must be accounted for when analyzing administrative data. The addition of laboratory data and present-on-admission codes can enhance the risk-adjustment capabilities of administrative data. While their potential to reduce diagnostic bias is not yet known, this may be the most important step in standardizing claims-based case definitions. Administrative claims data provide an opportunity to analyze large, nationally representative samples, but there are many challenges in their use that require careful consideration and ongoing research.

ACKNOWLEDGMENT
The authors thank Benjamin Vekhter, PhD for programming and data analysis, as well as Nicole Babuskow for administrative support, including Table and Figure creation. They are both affiliated with the Section of Hospital Medicine in the Department of Medicine at the University of Chicago.

References