BRIEF OBSERVATION

THE AMERICAN JOURNAL of MEDICINE®

# 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, PhD[c]**

*[a]Department of Medicine and [b]Department of Health Studies, University of Chicago, Ill; [c]Department 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 ($OR_{2005}$ 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.

 • *The American Journal of Medicine (2013) 126, 266-269*

**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.[2-5] However, a recent article by Lindenauer et al[6] 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

**Funding:** None.

**Conflict of Interest:** None.

**Authorship:** All authors had access to the data and played a role in writing the manuscript.

Requests for reprints should be addressed to Gregory W. Ruhnke, Department of Medicine, University of Chicago Medical Center, 5841 South Maryland Avenue, MC 5000, Chicago, IL 60637.

E-mail address: gruhnke@medicine.bsd.uchicago.edu

0002-9343/$ -see front matter 
http://dx.doi.org/10.1016/j.amjmed.2012.08.006

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,[3] 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,[6] we then selected patients with a principal diagnosis of sepsis (ICD-9-CM codes 038, 995.92, 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,[7] 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%; $OR_{2005}$ 0.62; 95% CI, 0.58-0.66), there was little

**Table** Characteristics of Pneumonia Hospitalizations by Principal Diagnosis

| | Pneumonia (n = 3,184,835) | | | Sepsis (n = 183,057) | | | Respiratory Failure (n = 185,345) | | |
|---|---|---|---|---|---|---|---|---|---|
| 1993-2005 | 1993-1995 (n = 637,853) | 2003-2005 (n = 796,517) | *P*-Value | 1993-1995 (n = 28,582) | 2003-2005 (n = 63,746) | *P*-Value | 1993-1995 (n = 22,669) | 2003-2005 (n = 67,192) | *P*-Value |
| Age (years) | | | <.001 | | | <.001 | | | <.001 |
| 18-49 | 98,163 (18.7) | 100,405 (14.5) | | 3742 (13.1) | 6880 (10.8) | | 1991 (8.9) | 7005 (10.4) | |
| 50-59 | 44,529 (8.5) | 77,800 (11.2) | | 1901 (6.7) | 6844 (10.7) | | 2165 (9.6) | 9147 (13.6) | |
| 60-69 | 81,276 (15.5) | 109,401 (15.8) | | 4111 (14.4) | 9900 (15.5) | | 5284 (23.3) | 14,622 (21.8) | |
| 70-79 | 136,069 (25.9) | 169,269 (15.6) | | 7583 (26.5) | 16,051 (25.2) | | 7565 (33.4) | 19,038 (28.3) | |
| 80-89 | 126,538 (24.1) | 178,263 (25.7) | | 8361 (29.3) | 17,824 (28.0) | | 4754 (21.0) | 14,178 (21.2) | |
| 90+ | 39,138 (7.4) | 58,458 (8.4) | | 2884 (10.1) | 6247 (9.8) | | 910 (4.0) | 3202 (4.8) | |
| Female, n (%) | 321,161 (50.4) | 417,297 (52.4) | <.001 | 14,968 (52.4) | 32,876 (51.6) | 0.025 | 11,482 (50.7) | 35,147 (52.3) | <.001 |
| Mean LOS, days (SD) | 7.3 (12.3) | 5.6 (5.9) | <.001 | 11.6 (15.4) | 10.2 (11.5) | <.001 | 15.0 (29.9) | 12.0 (14.7) | <.001 |
| Overall mortality | 43,907 (6.9) | 36,474 (4.6) | <.001 | 6867 (24.0) | 15,785 (24.8) | .016 | 6836 (30.2) | 15,286 (22.8) | <.001 |
| Mortality by age group | | | | | | | | | |
| 18-49 | 2892 (3.0) | 1534 (1.5) | <.001 | 511 (13.7) | 883 (12.8) | .231 | 422 (21.2) | 976 (13.9) | <.001 |
| 50-59 | 2180 (4.9) | 2194 (2.8) | <.001 | 352 (18.5) | 1297 (19.0) | .668 | 462 (21.3) | 1419 (15.5) | <.001 |
| 60-69 | 5473 (6.7) | 4040 (3.7) | <.001 | 828 (20.1) | 2132 (21.5) | .066 | 1327 (25.1) | 2663 (18.2) | <.001 |
| 70-79 | 11,787 (8.7) | 8760 (5.2) | <.001 | 1794 (23.7) | 3892 (24.3) | .322 | 2320 (30.7) | 4510 (23.7) | <.001 |
| 80-89 | 15,063 (11.9) | 13,470 (7.6) | <.001 | 2424 (29.0) | 5328 (29.9) | .137 | 1866 (39.3) | 4461 (31.5) | <.001 |
| 90+ | 6145 (15.7) | 6274 (10.7) | <.001 | 958 (33.2) | 2253 (36.1) | .008 | 439 (48.2) | 1257 (39.3) | <.001 |

LOS = length of stay.

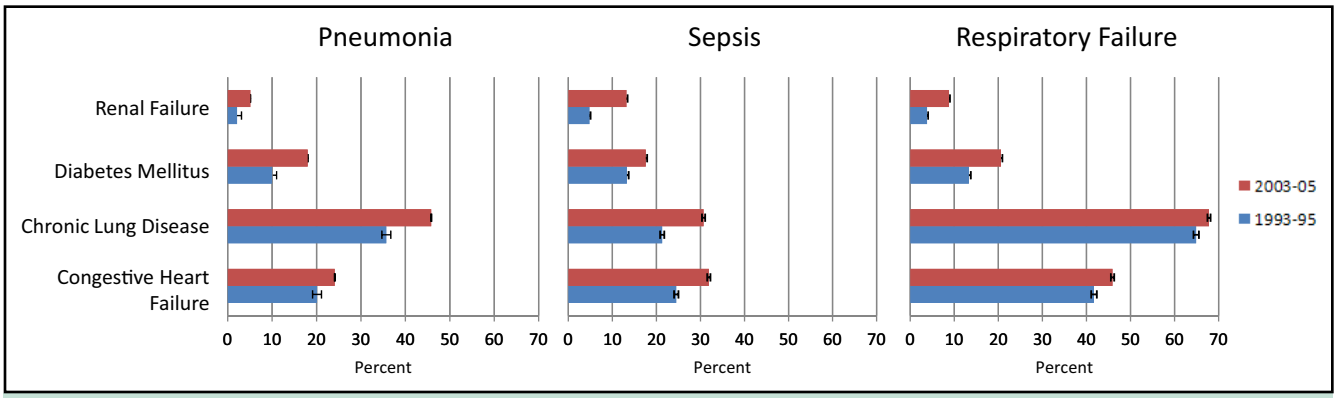


**Figure 1** Proportions of comorbid conditions among pneumonia hospitalizations by principal diagnosis for the periods 1993-1995 and 2003-2005.

change in mortality among principal-diagnosis sepsis hospitalizations (OMR 24.2%; $OR_{2005}$ 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 ($OR_{2005}$ 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,[3,5] 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[8,9]), 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[10]) increased from 54% to 88%.[11] 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.[3]

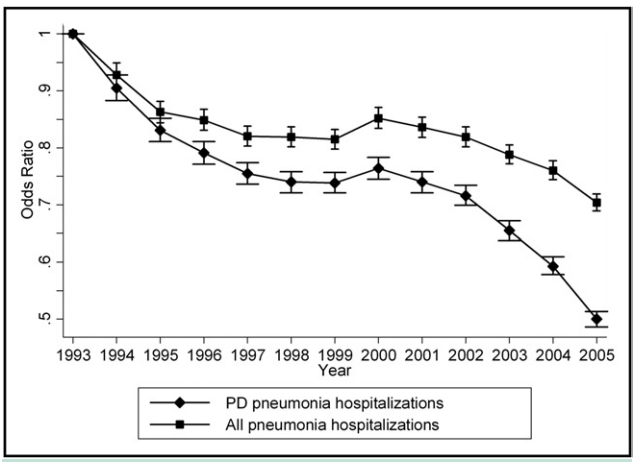


**Figure 2** Adjusted for age, sex, and comorbid conditions, the odds ratio of in-hospital death relative to reference year 1993 among principal-diagnosis (PD) pneumonia hospitalizations and the combined group of all pneumonia hospitalizations. Error bars indicate 95% confidence intervals.

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.[12] 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-

tices 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.[13] 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.[14] 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

1. Iezzoni LI, Foley SM, Daley J, Hughes J, Fisher ES, Heeren T. Comorbidities, complications, and coding bias. Does the number of diagnosis codes matter in predicting in-hospital mortality? *JAMA*. 1992;267:2197-2203.
2. Fry AM, Shay DK, Holman RC, Curns AT, Anderson LJ. Trends in hospitalizations for pneumonia among persons aged 65 years or older in the United States, 1988-2002. *JAMA*. 2005;294:2712-2719.
3. Ruhnke GW, Coca-Perraillon M, Kitch BT, Cutler DM. Trends in mortality and medical spending in patients hospitalized for community-acquired pneumonia: 1993-2005. *Med Care*. 2010;48:1111-1116.
4. Metersky ML, Tate JP, Fine MJ, Petrillo MK, Meehan TP. Temporal trends in outcomes of older patients with pneumonia. *Arch Intern Med*. 2000;160:3385-3391.
5. Ruhnke GW, Coca-Perraillon M, Kitch BT, Cutler DM. Marked reduction in 30-day mortality among elderly patients with community-acquired pneumonia. *Am J Med*. 2011;124:171-178.
6. Lindenauer PK, Lagu T, Shieh MS, Pekow PS, Rothberg MB. Association of diagnostic coding with trends in hospitalizations and mortality of patients with pneumonia, 2003-2009. *JAMA*. 2012;307:1405-1413.
7. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36:8-27.
8. Jackson LA, Neuzil KM, Yu O, et al. Effectiveness of pneumococcal polysaccharide vaccine in older adults. *N Engl J Med*. 2003;348:1747-1755.
9. Spaude KA, Abrutyn E, Kirchner C, Kim A, Daley J, Fisman DN. Influenza vaccination and risk of mortality among adults hospitalized with community-acquired pneumonia. *Arch Intern Med*. 2007;167:53-59.
10. Gleason PP, Meehan TP, Fine JM, Galusha DH, Fine MJ. Associations between initial antimicrobial therapy and medical outcomes for hospitalized elderly patients with pneumonia. *Arch Intern Med*. 1999;159:2562-2572.
11. Ramirez JA. Processes of care for community-acquired pneumonia. *Infect Dis Clin North Am*. 2004;18:843-859.
12. Whittle J, Fine MJ, Joyce DZ, et al. Community-acquired pneumonia: can it be defined with claims data? *Am J Med Qual*. 1997;12:187-193.
13. Bottle A, Jarman B, Aylin P. Hospital standardized mortality ratios: sensitivity analyses on the impact of coding. *Health Serv Res*. 2011;46:1741-1761.
14. Pine M, Jordan HS, Elixhauser A, et al. Enhancement of claims data to improve risk adjustment of hospital mortality. *JAMA*. 2007;297:71-76.