Published in final edited form as:

Crit Care Med. 2015 June ; 43(6): 1178–1186. doi:10.1097/CCM.0000000000000925.

Hospitals with the Highest Intensive Care Utilization Provide Lower Quality Pneumonia Care to the Elderly

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Abstract

Objective—Quality of care for patients admitted with pneumonia varies across hospitals, but causes of this variation are poorly understood. Whether hospitals with high intensive care unit (ICU) utilization for pneumonia patients provide better quality care is unknown. We sought to investigate the relationship between a hospital's ICU admission rate for elderly patients with pneumonia and the quality of care it provided to patients with pneumonia.

Design, Setting, and Patients—Retrospective cohort study of 2,812 US hospitals caring for at least 25 elderly (age ≥ 65) fee-for-service Medicare beneficiaries with either a (1) principal diagnosis of pneumonia or (2) principal diagnosis of sepsis or respiratory failure and secondary diagnosis of pneumonia in 2008.

Interventions—None.

Measurements and Main Results—We grouped hospitals into quintiles based on ICU admission rates for pneumonia. We compared rates of failure to deliver pneumonia processes of care (calculated as 100 – adherence rate), 30-day mortality, hospital readmissions, and Medicare spending across hospital quintile. After controlling for other hospital characteristics, hospitals in the highest quintile more often failed to deliver pneumonia process measures, including appropriate initial antibiotics (13.0% versus 10.7%, $p < 0.001$), and pneumococcal vaccination

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Dr. Sjoding and Dr. Cooke contributed to the study design, analysis and interpretation of data, writing and revising the manuscript and approval of the final manuscript.

Dr. Prescott, Dr. Wunsch, and Dr. Iwashyna contributed to the analysis and interpretation of data, revising the manuscript for important intellectual content and approval of the final manuscript.

(15.0% versus 13.3%, $p = 0.03$) compared to hospitals in quintiles 1–4. Hospitals in the highest quintile of ICU admission rate for pneumonia also had higher 30-day mortality, 30-day hospital readmission rates, and hospital spending per patient than other hospitals

Conclusion—Quality of care was lower among hospitals with the highest rates of ICU admission for elderly patients with pneumonia; such hospitals were less likely to deliver pneumonia processes of care and had worse outcomes for pneumonia patients. High pneumonia-specific ICU admission rates for elderly patients identify a group of hospitals that may deliver inefficient and poor quality pneumonia care, and may benefit from interventions to improve care delivery.

Keywords

Quality of Healthcare; Outcome Measures; Process Measures; Clinical Practice Variation; Critical Care

INTRODUCTION

Each year, approximately 1.1 million patients are hospitalized for pneumonia, amounting to more than \$10 billion in annual hospitalization costs [1]. Multiple studies demonstrate wide variation in the quality of care hospitals provide to patients with pneumonia, as measured by adherence to pneumonia process measures, mortality rates, and hospital readmission rates. At some hospitals, as many as one in three patients with pneumonia may not be receiving appropriate care [2–5]. Reasons for this variation in quality are less well understood, despite multiple investigations [6–11].

One aspect of care that may vary across hospitals and help explain differences in the quality of care provided to patients with pneumonia is the location where care is delivered. Intensive care is necessary for the most severely ill patients with pneumonia, but among the less ill there is no consensus as to who might benefit [12]. Since intensive care units (ICUs) have more ancillary resources and a mandated nurse to patient ratio of 2:1 or lower, patients may receive more guideline concordant, and better quality care in these settings. Hospitals admitting more patients to the ICU could be providing higher quality care to their patients with pneumonia. Alternatively, there are feasible mechanisms by which hospitals with high ICU admission rates may be providing lower quality of care. Hospitals with high ICU admission rates may be *proactively* admitting many patients to the ICU out of fear they would receive poor care elsewhere within the hospital, or *reactively* admitting patients to the ICU in an attempt to rescue them from clinical deterioration after receiving poor care elsewhere.

Characterizing the direction of the relationship between ICU admission rates and hospital quality has important implications. If hospitals with higher ICU utilization ultimately provide better quality care to patients with pneumonia, then perhaps more patients with pneumonia would benefit from the highly protocolized and resource intensive care typically provided in ICU settings. However, if high ICU use correlates with lower quality care, then hospitals with exceedingly high ICU use warrant closer inspection to understanding why this breakdown in care delivery is occurring.

To clarify these competing hypotheses, we investigated the relationship between pneumonia-specific ICU admission rates and the quality of care provided by hospitals for pneumonia. We assessed both processes of care measures, such as administration of appropriate antibiotics, and outcomes, including 30-day mortality, hospital readmission and hospital spending, as measures of hospital quality. We hypothesized that hospitals with higher ICU admission rates for pneumonia deliver lower quality of care for patients with pneumonia, more often failing to provide appropriate processes of care, with higher risk adjusted 30-day mortality, higher hospital readmission rate and higher average spending.

METHODS

Dataset Generation

We conducted a retrospective cohort study using discharge records of all acute care hospitalizations among elderly (age ≥ 65) fee-for-service Medicare beneficiaries identified in the 2008 Medicare Provider and Review (MedPAR) File linked to beneficiary identification numbers, which allowed for the determination of mortality and readmission rates after hospitalization. We identified a cohort of patients with a principal discharge ICD-9-CM diagnosis code of pneumonia (480.X, 481, 482.XX, 483.X, 485, 486, 487.0), or principal diagnosis of septicemia (038.X, 785.52, 995.92, 995.91) or respiratory failure (518.81, 518.82, 518.84, 799.1) and a secondary code for pneumonia, as recent evidence suggests hospitals vary in how pneumonia is coded [13]. Demographic data (age, sex, and race) were obtained from the MedPAR files. Comorbidities were determined using the method of Elixhauser using secondary ICD-9-CM codes from each hospitalization [14]. We assigned to each patient the median household income of their ZIP code as a surrogate for socioeconomic status (SES). Hospital characteristics were obtained from the American Hospital Association (AHA) Annual Survey [15] and the Healthcare Cost Report and Information System [16].

We limited our analysis to hospitals that billed for ICU care to Medicare Beneficiaries and could be linked to AHA Survey information. Similarly to methods used in hospital performance reporting, we excluded hospitals with fewer than 25 total pneumonia admissions because estimates at those hospitals may be unreliable due to small sample size. For patients transferred between hospitals during the course of care, outcomes were assigned to the transferring hospital, and patients discharged against medical advice were excluded from analysis [17].

Adjusted ICU Admission Rates for Pneumonia

The primary exposure variable in our analysis was the hospital's adjusted ICU admission rate for pneumonia. ICU admission rate was defined as the proportion of patients with pneumonia at a hospital admitted to the ICU, after risk-adjusting for baseline differences in patient characteristics, and reliability adjusting the estimate based on total number of admissions [18]. An ICU admission was defined as the presence of an ICU or coronary care unit room and board charge during the hospitalization, excluding intermediate care units. Hospitals were grouped into quintiles of ICU admission rate for analysis, with hospitals in the first quintile having the lowest rates of admission.

Pneumonia Process Measures

We linked hospital ICU admission rates to pneumonia process measure information available in Hospital Compare in 2008 [19]. We analyzed the four pneumonia process measures still currently measured today, which include appropriate initial antibiotics, blood culture prior to antibiotics, pneumonia vaccination, and influenza vaccination. Although measured in 2008, we excluded oxygen saturation measurement, antibiotics within 6 hours, and smoking cessation counseling from the analysis because these measures have been retired from more recent pneumonia process measure reports. Since we were interested in whether hospitals failed to deliver pneumonia processes of care, we calculated and reported process measure failure rates, defined as 100 minus the adherence rate.

Patient Outcomes

We defined 30-day mortality as death within 30 days of the hospital admission date. Thirty-day readmission was defined as any admission to an acute care hospital within 30 days of discharge among patients who survived the index hospitalization for pneumonia. We used the reimbursement amount for each hospitalization paid by Medicare for spending analysis.

Statistical Analysis

To calculate hospital-specific ICU admission rates for pneumonia, we used the same statistical approach to risk adjustment that CMS uses to calculate hospital risk-standardized mortality and readmission rates [18]. This method estimates hospital-specific rates that are both *risk- and reliability adjusted*. By risk-adjusting rates, we controlled for any baseline patient differences between hospitals including age, sex, and race. By reliability adjusting rates, we accounted for the fact that the ICU admission rate estimates at hospitals with a lower number of patients may be less accurate [20]. A reliability-adjusted rate is a weighted average of the hospital's observed rate and the overall average rate among all hospitals. For hospitals with many patients, their reliability-adjusted rate is weighted almost entirely on their observed rate, but for hospitals with only a few patients, their reliability-adjusted rate is weighted more heavily on the population average, because we have less information available to estimate these hospital's rates.

Calculating risk- and reliability adjusted rates using CMS method's is similar to calculating an "observed" over "expected" rate, but uses a hierarchical logistic regression framework, adjusting for situations where a low number of observations at an individual hospital makes that hospital's result less reliable. A "predicted" probability of ICU admission is calculated for each patient, accounting for patient's characteristics and the hospital to which they were admitted. The "predicted" probabilities are summed over all patients at a hospital and divided by the sum of all "expected" probabilities of admission, which is estimated from only patient characteristics. The ratio is multiplied by the overall ICU admission rate for the entire cohort to obtain the adjusted ICU admission rate.

We presented ICU admission rates using a caterpillar plot. We compared patient and hospital characteristics across quintiles of ICU admission rate using chi-squared or ANOVA tests as appropriate. We entered patient and hospital-level factors into a random effects

logistic regression model to quantify the factors independently associated with higher odds of an ICU admission, setting hospital as the random effect.

To investigate whether ICU admission rate was associated with pneumonia process measure failure rates, we entered ICU admission rate quintile into a series of multivariable linear regression models with robust confidence interval estimates. ICU admission rate quintile was the primary exposure, process measure failure rate was the outcome, and hospital was the unit of analysis. We performed a Wald test to evaluate if ICU admission rate quintile was associated with each process measure failure rate. We used predictive margins to plot process measure failure rates and 95% confidence intervals across quintiles, adjusted for other hospital characteristics. Because we identified a non-monotonic relationship in process measure failure rates across quintiles, in a post hoc analysis we compared process measure failure rates in quintile five versus all other quintiles grouped and individually.

When examining the relationship between ICU admission quintile and 30-day mortality, 30-day readmission and spending, we used generalized estimating equations with a logit (mortality and readmission) and identity (hospitalization cost) link [21]. Each model was fit using robust confidence interval estimates and an exchangeable correlation data structure. We then calculated predictive margins across quintiles of hospital ICU admission rate, adjusted for other patient and hospital characteristics.

Patient level risk-adjustment included age, sex, race, and all comorbidities. Hospital-level risk adjustment included hospital characteristics with a plausible relationship with ICU admission rates and quality [22]. We included teaching status (high, low and none), defined as hospitals with membership in the college of teaching hospitals (COTH), presence of a residency program regardless of COTH membership; hospital profit status (government, private non-profit, private for profit), Medicaid admissions as a percentage of total, volume of pneumonia admissions, number of hospital beds, ratio of ICU to total hospital beds, nurse to patient ratio defined as the number of full time equivalent (FTE) registered nurses divided by total patient days in thousands, and the proportion of non-white admissions.

All data management and analysis was conducted using SAS 9.2 (SAS Institute, Cary, NC) and Stata 13 (StataCorp, College Station, Tx). The institutional review board of the University of Michigan approved the study.

RESULTS

Patient and Hospital Characteristics

After exclusions, we identified 551,873 patients hospitalized with pneumonia within 2,812 acute care hospitals that had at least one critical care admission and provided information to AHA in 2008 (eFigure 1, supplemental digital content). After risk- and reliability adjustment, the median hospital admitted 23% (range 2% to 86%) of pneumonia patients to the ICU (eFigure 2, supplemental digital content). Hospitals in the lowest quintile of ICU admission had rates less than 17%, while hospitals in the highest quintile ranged from 30% to 86%, but only 5% of all hospitals had rates greater than 41%. Lowest quintile hospitals tended to have a higher volume of pneumonia admissions, whereas highest quintile hospitals

had higher percentages of ICU beds and higher percentages of Medicaid patients (Table 1). Race and SES differed across hospital quintiles, with higher quintile hospitals caring for more non-white and lower SES patients (Table 2).

Factors Associated with an Increased Likelihood of ICU Admission

After adjusting for hospital and patient characteristics, several factors were independently associated with a higher likelihood of ICU admission (Table 3). Among patient comorbidities, congestive heart failure strongly increased the likelihood of ICU admission (OR 1.48, 95% CI 1.67–1.79). However, increasing age decreased the likelihood of ICU admission, similar to previous findings [23]. Among hospital characteristics, ICU admission was more likely at hospitals with more than 11% ICU beds as a percentage of total hospital beds compared to hospitals with less than 8% (OR 1.29, 95% CI 1.20–1.40). ICU admission was also more likely at hospitals with lower volume of pneumonia, and higher proportion of Medicaid or non-white admissions.

Pneumonia Process Measure Failure Rates and Patient Outcomes

ICU admission rate quintile was significantly associated with failure to deliver appropriate initial antibiotics ($p = 0.001$), pneumococcal vaccine ($p = 0.01$), but not influenza vaccination ($p = .08$) or blood culture prior to antibiotics ($p = 0.19$). Generally, process measure failure rates were notably higher in quintile five, despite otherwise having been flat or decreasing across earlier ICU admission quintiles (Figure 1). When comparing hospitals in quintile five to all other hospitals, we found quintile five to have higher failure rates of providing appropriate initial antibiotics (13% versus 11.4%, $p < 0.001$), pneumococcal vaccine (15.3% versus 13.4%, $p = 0.001$), and influenza vaccine (19.8% versus 18%, $p = 0.007$) (Table 4). Comparisons of quintile five hospitals with other quintiles individually are presented in the online digital content (eTable 1).

After adjusting for differences in patient and hospital characteristics, we found a statistically significant increase in 30-day mortality rates (16.8% to 18.9%, p for trend < 0.001) and 30-day hospital readmission rates (18.8% to 19.9%, p for trend < 0.001), when moving across quintiles from lower to higher ICU admission rate (Table 5). Medicare payment for pneumonia hospitalizations increased as well, with the mean payment increasing from \$9,320 among first quintile hospitals to \$10,666 in fifth quintile hospitals (p for trend < 0.001).

DISCUSSION

We found wide variation in ICU admission rates for elderly patients with pneumonia and hospitals with highest ICU admission rates provided lower quality of care to their patients. At hospitals with the highest ICU admission rate, pneumonia process measures were delivered less frequently, including appropriate initial antibiotics, pneumococcal vaccination, and influenza vaccination. Compared to hospitals with lower ICU admission rates for pneumonia, hospitals with higher ICU admission rates also had higher Medicare expenses, higher risk-standardized 30-day mortality, and higher 30-day readmissions rates for elderly patients with pneumonia.

A growing body of literature demonstrates that ICU admission rates vary widely across hospitals for multiple conditions. Recent studies have shown that ICU admission rates vary widely for all-comers [24], patients with diabetic ketoacidosis [25], congestive heart failure [26], pulmonary embolism [27], and acute myocardial infarction [28]. In these studies, despite wide variations in ICU admission rates, there was no difference in risk-adjusted mortality. The lack of mortality differences in these previous studies could be due to one of two competing hypothesis: 1) the ICU provided low marginal benefit for study patients, so hospitals with high ICU utilization were admitting patients that did not receive added benefit from critical care services, or 2) there was an unobserved heterogeneity in patients such that hospitals with high ICU utilization actually had sicker patients, but attained similar mortality rates by admitting them to the ICU. If the latter hypothesis is true, one would expect high ICU use hospitals to be providing high quality care to attain an average mortality rate. However, our results suggest that high ICU use hospitals may be providing lower quality care to their patients, at least in the case of pneumonia.

Our study is the first to more closely evaluate the care provided at high ICU use hospitals. Our results suggest that hospitals with greater ICU admission rates for patients with pneumonia, on average, provide lower quality of care to all admitted patients with pneumonia. This is illustrated by the greater process-of-care failure rates, higher risk adjusted mortality, expense, and readmission rates among patients in hospitals as the ICU admission rate increases. Although it is possible that the higher mortality rates, readmission rates, and expenses in high ICU use hospitals could be explained by inadequate patient-level risk adjustment, pneumonia process of care failure rates should not be.

Our results advance the literature that describes significant variation in ICU admission rates by providing evidence that hospitals with high admission rates may be providing lower quality care. Further research is necessary to unpack the mechanism by which hospitals admitting a high proportion of elderly patients with pneumonia to the ICU may be providing lower quality care for these patients. Hospitals may be admitting more patients to the ICU proactively or reactively in response to the poor care delivered elsewhere within the hospital. In either case, we speculate that these hospitals may be trying to use the ICU as a backstop against such care. It is also notable that these hospitals more often care for low SES and minority patients, raising concern that they may not have the resources to deliver high quality care. As more efforts are directed toward improving the quality of inpatient medical care while containing hospitalizations costs, understanding where and how pneumonia care delivery breaks down at these high-ICU use hospitals is of critical importance.

ICU admission rates are easily calculated using administrative data and may provide a unique window into the delivery of pneumonia care at individual hospitals. We do not advocate that ICU admission rates become a reportable quality measure or reimbursement target. However, a high ICU admission rate may serve as a warning signal for hospital administrators and healthcare analysts. Our data suggests that hospitals with high ICU admission rates for pneumonia should take a close look at the care they are providing to evaluate for possible deficiencies.

Our study should be interpreted in the context of several limitations. First, because of the nature of our dataset, we are unable to measure patient severity of illness on admission, and could only adjust for information available in administrative claims. However, we employed similar risk adjustment methods used by CMS to generate risk-adjusted hospital-level mortality rates for pneumonia, which has been shown to accurately reflect mortality derived from clinical charts [29]. However, future studies should seek to use more detailed risk adjustment when making comparisons between hospitals. We were unable to evaluate the time lapsed between hospital and ICU admission, which should also be evaluated in further studies. Second, adherence to the pneumonia process measures, risk-adjusted hospital mortality and readmission rates may not accurately reflect the quality of care provide at an individual hospital. Nonetheless, these measures are endorsed by the National Quality Forum, are publicly reported on CMS's Hospital Compare website, and are used in several pay for performance programs by CMS. As such, they are the accepted CMS standard for payers to characterize hospital quality. Nevertheless, subsequent studies in this area should seek to characterize adherence to strong recommendations from clinical practice guidelines as the best measure of quality. Third, our results could be subject to residual confounding due to other unmeasured patient and hospital characteristics.

CONCLUSIONS

In conclusion, our study suggests that hospitals with highest ICU utilization for pneumonia on average perform worse on pneumonia process measures, and have higher mortality, expenses, and readmission rates compared to all other hospitals. Researchers and policy makers should examine these poor performing hospitals to better understand why these deficiencies are occurring, and develop interventions to improve the care delivered at these higher cost hospitals.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding Information: Dr. Sjoding and Dr. Prescott T32HL007749, Dr. Wunch K08AG038477, Dr. Iwashyna Department of Veterans Affairs Health Services Research & Development Services - IIR 11-109, NIH R21AG044752, Dr. Cooke K08HS020672

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Figure 1.

Pneumonia process measure failure rates and 95% confidence interval estimates across hospital quintiles of (ICU) admission rates for elderly patients with pneumonia. Results are adjusted for the following hospital characteristics: volume of pneumonia admissions, number of hospital beds, ICU to hospital bed ratio, patient to nurse ratio, teaching status, profit status, proportion of Medicaid admissions, and proportion of non-white admissions.

Table 1
Hospital Characteristics Across Quintiles of Intensive Care Admission Rates for Pneumonia

	First Quintile (n = 562) (<17%)	Second Quintile (n = 562) (17%–21%)	Third Quintile (n = 561) (21%–25%)	Fourth Quintile (n = 562) (25%–30%)	Fifth Quintile (n = 561) (30%–86%)	p
PNA ICU admission rate ^a	206	212	202	187	176	<0.001
Mean PNA Admissions						
Profit Status						
Government	14.4	14.4	15.5	15.1	16.9	<0.001
Private non-profit	72.1	69.8	65.8	65.5	60.1	
Private for-profit	13.5	15.8	18.7	19.4	23.0	
Total Hospital Beds						
<100	26.7	24.7	26.4	21.4	20.5	<0.001
100–399	61.0	62.1	57.0	62.3	60.8	
400 +	12.3	13.2	16.6	16.4	18.7	
Teaching Status						
None	72.1	65.5	65.6	57.5	56.5	<0.001
Low (any FTE residents)	20.3	27.1	26.4	30.1	31.7	
High (COTH member)	7.7	7.5	8.0	12.5	11.8	
ICU Beds ^b						
< 8%	43.2	37.7	33.2	28.8	27.8	<0.001
8%–11%	29.4	35.6	37.4	30.8	29.4	
>11%	27.4	26.7	29.4	40.4	42.8	
Hospital Location						
Urban	51.3	55.3	51.7	53.7	50.5	<0.001
Non-urban	48.8	44.7	48.3	46.3	49.6	
Nurse Staffing						
Nurse staffing ratio ^c	3.6	3.6	3.6	3.5	3.7	0.4
Payor mix						
Percent Medicaid	8.5	9.0	10.0	10.8	11.7	<0.001

PNA, Pneumonia; ICU, Intensive Care Unit; FTE, Full-time equivalent; COTH, Counsel of Teaching Hospitals.

Data are percentages unless otherwise indicated;

number of full-time equivalent nurses divided by number of patient days in thousands.

ICU beds as a Percentage Total Hospital Beds;

rates are risk and reliability adjusted;

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Table 2
Patient Characteristics Across Quintiles of Intensive Care Admission Rates for Pneumonia

	First Quintile (n=115,594) (<17%)	Second Quintile (n=119,215) (17%–21%)	Third Quintile (n=113,368) (21%–25%)	Fourth Quintile (n=105,038) (25%–30%)	Fifth Quintile (n=98,568) (30%–86%)	p
PNA ICU admission rates ^a						
Age						
65 – 74	28.8	29.3	30.3	30.3	30.5	<0.001
74 – 84	38.0	38.3	37.9	37.7	37.6	
>84	33.2	32.4	31.8	32.0	31.9	
Gender						
Male	45.19	45.99	45.42	45.56	46.06	<0.001
Female	54.81	54.01	54.58	54.44	53.94	
Race						
White	89.7	89.7	86.8	83.2	82.3	<0.001
Black	10.3	10.4	13.0	17.4	17.7	
Select Comorbidities						
Congestive Heart Failure	29.3	29.0	28.7	28.3	28.1	<0.001
Pulmonary Circulatory Disease	4.0	4.1	3.9	3.9	3.8	<0.001
Chronic Pulmonary Disease	43.5	43.3	43.2	41.9	41.9	<0.001
Renal Failure	12.8	13.1	13.3	13.3	13.3	0.005
Metastatic Cancer	3.4	3.3	3.3	3.4	3.2	0.044
Coagulopathy	14.4	14.7	15.5	15.6	15.7	0.227
Weight Loss	8.2	7.8	7.7	8.2	7.5	<0.001
Income Quartile ^b						
First (lowest)	23.0	23.8	25.6	25.8	27.3	<0.001
Second	24.6	25.2	26.0	24.6	24.5	
Third	25.7	25.9	25.2	24.4	23.6	
Fourth (highest)	26.7	25.2	23.2	25.2	24.6	

Data are percentages unless otherwise stated;

^aICU admission rates are risk and reliability adjusted;

^bPatients were assigned Median household income of their ZIP code, then divided into quartiles.

Table 3

Patient and Hospital Factors Associated with a Higher Likelihood of ICU Admission

	Odds Ratio ^a	95% CI
Patient Factors		
Male	1.07	(1.05–1.08)
Age		
65–74	Reference	
75–84	0.75	(0.73–0.76)
>85	0.47	(0.46–0.48)
Non-white	1.14	(1.11–1.16)
Comorbidities ^b		
Congestive Heart Failure	1.48	(1.46–1.5)
Pulmonary Circulatory Disease	1.21	(1.17–1.25)
Chronic Pulmonary Disease	0.83	(0.82–0.84)
Renal Failure	0.8	(0.77–0.82)
Metastatic Cancer	0.82	(0.79–0.85)
Coagulopathy	1.35	(1.31–1.4)
Weight Loss	1.57	(1.54–1.61)
Admit Type		
Emergent	Reference	
Urgent	0.62	(0.61–0.64)
Elective	0.69	(0.66–0.72)
Admit Source		
Emergency Department	Reference	
Outpatient	0.85	(0.82–0.87)
Nursing Facility/Other	1.18	(1.13–1.22)
Hospital Factors		
Profit Status		
Government	Reference	
Private non-profit	0.99	(0.92–1.06)
Private for-profit	1.03	(0.95–1.12)
Teaching Status		
None	Reference	
Low (Any FTE Residents)	0.98	(0.92–1.04)
High (COTH member)	0.91	(0.83–1.01)
Volume of PNA Admissions		
Low (< 100)	Reference	
Moderate (100 – 200)	0.93	(0.87–0.99)
High (>200)	0.81	(0.76–0.87)
ICU Beds as % of Total		
Low (< 8%)	Reference	
Moderate (8% – 11%)	1.11	(1.05–1.18)

	Odds Ratio^a	95% CI
High (> 11%)	1.24	(1.17–1.32)
Proportion Medicaid Admits		
Low (< 7%)	Reference	
Moderate (7% – 11%)	1.07	(1.01–1.14)
High (> 11%)	1.13	(1.06–1.21)
Proportion Non-white Admits		
Low (< 4%)	Reference	
Moderate (4% – 14%)	1.03	(0.97–1.09)
High (> 14%)	1.21	(1.13–1.29)
Nurse Staffing Ratio		
Low	Reference	
Moderate	0.94	(0.89–1)
High	0.92	(0.87–0.98)

COTH, Council of Teaching Hospitals; FTE, Full Time Equivalent.

^aData are presented as the odds ratio associated with ICU admission obtained from a hierarchical logistic regression model adjusting for all patient and hospital characteristics presented and all 30 Elixhauser comorbidities, treating hospital as a random intercept.

^bSelect comorbidities are presented.

Table 4

Process measure failure rates at hospitals in the fifth (highest) quintile of ICU admission rate for pneumonia compared with all other hospitals

Process measures (% failure rate)	First-fourth quintile of ICU admission (< 30% ICU admission rate)	Fifth quintile of ICU admission (> 30% ICU admission rate)	<i>p</i>
Appropriate antibiotics	11.4	13.0	< 0.001
Blood culture prior to antibiotics	7.7	8.3	0.08
Pneumococcal vaccination	13.4	15.3	0.001
Influenza vaccination	18.0	19.8	0.007

^aFailure rates were the estimated predicted marginal effects from multivariable linear regression models, where quintile five was the primary exposure and process measure failure rate was the outcome, adjusting for other hospital characteristics as described in the manuscript text.

Table 5

30-day Mortality Rate, 30-day Hospital Readmission Rate, and Medicare Spending Across Hospital Quintiles of Intensive Care Admission Rates for Pneumonia

Adjusted Outcomes ^a	First Quintile (<17%)	Second Quintile (17%–21%)	Third Quintile (21%–25%)	Fourth Quintile (25%–30%)	Fifth Quintile (30%–86%)	P for trend
30-Day Mortality Rate	16.8%	17.6%	18.2%	18.7%	18.9%	<0.001
30-Day Readmission Rate	18.8%	19.5%	19.7%	19.6%	19.9%	<0.001
Spending (in dollars)	9,320	9,705	9,762	9,944	10,666	<0.001

^a Outcomes were the estimated predicted marginal effects from multivariable linear regression models, after adjusting for other patient and hospital characteristics as described in the manuscript text.