Association of Early Do-Not-Resuscitate Orders with Unplanned Readmissions among Patients Hospitalized for Pneumonia

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Abstract

Rationale: In the United States, approximately 20% of patients hospitalized with pneumonia are readmitted to a hospital within 30 days. Given the significant costs and healthcare system use resulting from unplanned readmissions, pneumonia readmission rates are a target of national quality measures. Patient do-not-resuscitate (DNR) status strongly influences hospital pneumonia mortality measures; however, associations between DNR status and 30-day readmissions after pneumonia are unclear.

Objectives: Determine the effect of accounting for patient DNR status on hospital readmission measures for pneumonia.

Methods: After excluding patients with missing data, those who died during the index hospitalization, those who were discharged against medical advice, those who did not reside in California, and those admitted to low pneumonia case-volume hospitals, we identified 30-day unplanned readmissions after an index pneumonia hospitalization from the 2011 California State Inpatient Database. We used hierarchical logistic regression to determine the association between early DNR status (within 24 hours of admission) and 30-day readmission and hospital risk-adjusted readmission rates.

Measurements and Main Results: We identified 68,691 hospitalizations for pneumonia across 321 hospitals. Patients with early DNR orders were less likely to be readmitted within 30 days (20.0% vs. 22.5%, adjusted odds ratio [aOR], 0.93; 95% confidence interval [CI], 0.88–0.99). Patients with pneumonia admitted to high-versus-low DNR rate hospitals were at lower risk for readmission (DNR rate quartile 4 vs. quartile 1, aOR, 0.62; 95% CI, 0.55–0.70), regardless of individual DNR status. Higher hospital risk-adjusted DNR rates were strongly associated with lower risk-adjusted readmission rates ($r = -0.44$; $P < 0.0001$). Inclusion of early DNR status in risk-adjusted readmission models changed ranking categories for 7/321 (2.2%) hospitals, with 2 hospitals no longer labeled as “under-performing outliers.”

Conclusions: Patients with an early DNR order have a lower risk for readmission after a pneumonia hospitalization. Unmeasured DNR status weakly confounds hospital readmission measures; accounting for patient DNR status would alter readmission ratings for a small number of hospitals.

Keywords: advance directives; health care quality, access, and evaluation; health care quality indicators

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More than 1 million adults are hospitalized with pneumonia in the United States each year (1). In addition to substantial mortality risks, around 20% of survivors of pneumonia hospitalizations are readmitted within 30 days of discharge, at a cost exceeding \$1 billion annually (2). Pneumonia is the second leading cause of 30-day readmissions in the United States among older individuals (3). Given the major healthcare use and cost implications of pneumonia readmissions (4, 5), the Center for Medicare & Medicaid Services (CMS) Hospital Readmission Reduction Program has designated 30-day unplanned pneumonia readmission rates as a core hospital quality measure, with financial penalties for underperforming hospitals (6).

Although eliciting patient goals of care is considered an aim of high-quality healthcare, patient preferences for life-sustaining treatments (e.g., do-not-resuscitate [DNR] orders) are generally unaccounted for in measures of hospital quality. Early DNR status (orders placed within 24 hours of admission) can confound evaluations of healthcare delivery (7) because of strong correlations with in-patient mortality (7, 8). At this time, CMS does not adjust for patient early DNR status on the basis of the potential correlation with other comorbidity measures (9). However, associations of DNR status with unplanned 30-day readmission rates after an index hospitalization for pneumonia are unclear.

As DNR rates vary widely between hospitals (8), an association between early DNR status and readmissions could have a significant effect on hospital quality measures. We used a large, population-based administrative database to investigate the association of DNR status with 30-day readmission after pneumonia hospitalization and evaluate the effect of DNR status on readmission quality measures. DNR status may be associated with greater likelihood to experience out-of-hospital death, discharge to hospice, or “do-not-hospitalize” orders. Therefore, we hypothesized that patients with early DNR orders would have lower 30-day readmission rates, that hospitals with higher DNR rates would have lower readmission rates, and that adjustment for DNR status would worsen readmission rankings for hospitals with high DNR rates compared with rankings from standard-quality models that do not account for patient DNR status.

Methods

Please see the online supplement for full study details.

Patients

Using the Healthcare Cost and Utilization Project’s California State Inpatient Database (10), we conducted a retrospective cohort study analyzing adults age 65 years or older who survived a hospitalization with pneumonia in 2011. In addition to administrative discharge data, the California State Inpatient Database is unique in that it captures DNR orders placed within 24 hours of hospital admission with 85% accuracy (11, 12). Pneumonia hospitalizations were identified from billing codes using previously validated algorithms (see Table E1 in the online supplement) (13). We excluded patients with missing readmission or DNR information, who died during the index hospitalization, with residence outside of

California, who were transferred to another acute care facility or who left against medical advice, or who were admitted to hospitals with fewer than 25 pneumonia cases in 2011 (6, 14).

Do-Not-Resuscitate Status

Our primary exposure was early DNR status. We captured patient-level early DNR orders and characterized hospital-level early DNR rates (number of patients with pneumonia with an early DNR order divided by the total number of patients with pneumonia admitted at each hospital).

Outcomes

Our primary outcome was 30-day unplanned readmissions after a pneumonia hospitalization (6). We evaluated the association of patient DNR status with 30-day readmission. We also evaluated associations between hospital-level early DNR rates with risk-adjusted, patient-level 30-day unplanned readmission risk and hospital-level risk-adjusted readmission

Figure 1. Study design: 85,362 index hospitalizations for pneumonia were identified from the California State Inpatient Database from 2011, after excluding patients with missing data, patients who died during the index hospitalization, patients who did not live in California, patients transferred to another acute care hospital or who left against medical advice (AMA), and patients admitted to hospitals that care for fewer than 25 cases of pneumonia in 2011. The final cohort included 68,691 hospitalizations for pneumonia across 321 hospitals in California in 2011. CA = California; DNR = do not resuscitate.

rates. We explored the change in pneumonia readmission hospital rankings after inclusion of patient early DNR status in risk-adjustment models.

Statistical Analysis

Summary patient-level data across hospital DNR rate quartiles was presented as mean (standard deviation) or median (interquartile range) for continuous variables and percentages for categorical variables. We tested for trends across quartiles, using the Cochran-Armitage test for trend and Mantel-Hanenszel chi-square test for categorical variables, and linear regression for continuous variables. We used multivariable hierarchical logistic regression models (15) with the hospital as a random intercept to calculate hospital risk-adjusted early DNR and 30-day readmission rates and to determine the association of hospital DNR use with the risk for readmission within 30 days of discharge.

We used similar models with the hospital as a random intercept and patient early DNR status as a random slope to determine the association of patient-level DNR status with readmission risk and to calculate risk-adjusted readmission rates modified by inclusion of patient early DNR status. We adjusted models for patient demographics, individual Elixhauser comorbidities (16, 17), and acute organ failures present on admission (Table E2) (18, 19). To explore whether hospital early DNR rates may be a surrogate for other unmeasured factors that might reduce readmissions, we analyzed the association between hospital DNR rates and readmission among patients without an early DNR order. We used Spearman correlation to determine the association between hospital risk-adjusted DNR rates and risk-adjusted readmission rates and quadratic spline regression to visualize hospital-level relationships.

To determine the degree to which patient DNR status is an unmeasured confounder in hospital quality measures for pneumonia readmissions, we used change in rank and ranking category (defined as underperformer, average, or better than average, based on being greater or less than 2 standard deviations from the average unadjusted California hospital readmission rate, similar to CMS methodologies) (14). We used linear regression to compare hospital risk-adjusted readmission rates

calculated with and without DNR as a covariate.

Sensitivity Analysis

We conducted a sensitivity analysis, restricting our cohort to patients with a principal diagnosis for pneumonia, a schema previously used by CMS to identify pneumonia hospitalizations. Accounting for race, socioeconomic status, or acute illness severity in hospital quality measures is controversial (6, 14); we conducted a sensitivity analysis, removing markers of socioeconomic status and acute organ failures from models and limiting covariates to age, sex, and comorbidities. We conducted an additional sensitivity analysis excluding patients admitted or discharged in the month of December, as we could not track patients for a full 30 days after discharge with data limited to 2011 (3). Finally, we excluded patients admitted to hospitals with crude early DNR rate higher than 50%, as it was unclear whether these hospitals potentially provided inpatient palliative or hospice services.

The study was deemed exempt from review by the Boston University Medical Campus institutional review board. All statistical analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC) at a critical two-tailed alpha level of 0.05.

Results

We identified 85,253 hospitalizations for pneumonia in California during 2011. After exclusions, our final cohort contained 68,691 index hospitalizations for pneumonia across 321 hospitals in California (Figure 1). Among all patients aged 65 years or older hospitalized with pneumonia, 18.0% had an early DNR order. At the hospital level, the average of the individual hospital risk-adjusted early DNR rates was 21.4%, but rates varied widely between hospitals (range, 1.1–84.0%) (Figure 2). Patients admitted to hospitals with higher DNR rates tended to be slightly older and were more likely to be white, more likely to have Medicare, and more likely to live in high-income neighborhoods (Table 1) (20). We observed a statistically significant trend toward patients having lower comorbidity scores and lower rates of acute organ failures on presentation at high DNR rate hospitals.

Patient-Level Readmission

Among patients with pneumonia who survived to hospital discharge, 22.1% were readmitted within 30 days. Patients who required readmission tended to be female, black, and living in lower-income neighborhoods, with more comorbidities and acute organ failure (Table E3). Patients with an early DNR order had lower unadjusted 30-day readmission rates (20.0%

Figure 2. Hospital risk-adjusted early DNR rates for patients hospitalized for pneumonia. The x-axis intersects the y-axis at 17.1%, the average unadjusted hospital early DNR rate. Error bars indicate 95% confidence interval toward the national average hospital DNR rate only for hospitals with rates statistically different from the average hospital. DNR = do not resuscitate.

Table 1. Patient characteristics across hospital early DNR quartile

Variable	Hospital DNR Rate Quartile				P Value*
	1 <8.2%	2 8.2–16.1%	3 16.1–26.7%	4 ≥ 26.7%	
Number of patients	17,347	17,332	16,434	17,578	NA
Number of hospitals	98	79	72	72	NA
Early DNR, %	4.8	12.4	20.1	34.5	<0.0001
Age, yr, mean (SD)	79.2 (7.9)	79.9 (7.9)	79.7 (8.1)	80.1 (7.9)	<0.0001
Female, %	52.2	53.6	53.7	52.1	0.40
Race/ethnicity					<0.0001
White	49.3	57.4	66.9	76.7	
Black	9.3	5.3	5.3	3.5	
Hispanic	21.1	21.3	14.5	8.1	
Other [†]	20.3	16.0	13.3	11.7	
Primary payer					<0.0001
Medicare	88.5	88.5	90.1	93.4	
Medicaid	5.7	5.6	3.6	1.4	
Private insurance	5.1	5.3	5.4	4.8	
Other [†]	0.7	0.6	0.9	0.4	
Median income [‡]					<0.0001
Lower quartile	38.4	24.0	27.8	14.1	
Low middle quartile	25.7	27.9	25.2	21.7	
Upper middle quartile	23.7	24.4	24.7	32.6	
Upper quartile	11.0	22.5	23.5	30.2	
Other [†]	1.2	1.1	1.6	1.5	
Elixhauser score, mean (SD) [§]	10.0 (7.5)	10.0 (7.5)	9.4 (7.2)	9.8 (7.5)	<0.0001
Shock POA	10.4	10.9	9.3	8.4	<0.0001
Acute respiratory failure POA	18.9	17.5	15.0	13.7	<0.0001
Acute renal failure POA	19.4	19.3	18.2	16.3	<0.0001
Acute neurologic failure POA	10.2	8.9	6.1	6.3	<0.0001
Acute hepatic failure POA	0.7	0.5	0.6	0.5	0.01
Acute hematologic failure POA	6.1	6.9	6.0	7.1	0.01
Acute metabolic acidosis POA	5.5	6.4	4.7	6.3	0.27

Definition of abbreviations: DNR = do not resuscitate; POA = present on admission; SD = standard deviation.

*Test for trend across quartiles.

[†]Includes patients with missing data.

[‡]Median income of zip code of residence.

[§]Calculated without cardiac arrhythmia comorbidity per Healthcare Cost and Utilization Project's software (20).

vs. 22.5%; $P < 0.0001$). In multivariable-adjusted analysis, early DNR status remained associated with a lower odds of 30-day readmission (adjusted odds ratio [aOR], 0.93; 95% confidence interval [CI], 0.88–0.99). Regardless of patient-level DNR status, patients admitted to a high- versus low-DNR-use hospital had lower odds of 30-day readmission (hospital DNR rate quartile 4 vs. quartile 1, aOR, 0.62; 95% CI, 0.55–0.70). Patients with an early DNR order (hospital DNR rate quartile 4 vs. quartile 1, aOR, 0.74; 95% CI, 0.59–0.91) and patients without an early DNR order (hospital DNR rate quartile 4 vs. quartile 1, aOR, 0.63; 95% CI, 0.56–0.71) admitted to high- versus low-DNR-use hospitals had lower odds of 30-day readmission.

Hospital-Level Readmission Rates

The average hospital risk-adjusted 30-day readmission rate was $19.0 \pm 4.7\%$, with a

3.5-fold variation between hospitals with the lowest and highest risk-adjusted readmission rate (Figure 3). Higher hospital risk-adjusted early DNR rates were associated with lower risk-adjusted readmission rates for all patients with pneumonia ($\rho = -0.44$; $P < 0.0001$; Figure 4), including patients without early DNR orders ($\rho = -0.39$; $P < 0.0001$; Figure E1). When patient DNR status was included in readmission risk-adjusted models, higher hospital risk-adjusted DNR rates continued to be associated with lower risk-adjusted readmission rates ($r = -0.41$; $P < 0.0001$; Figure E2).

Hospital Quality Rankings

In the standard hospital readmission model without accounting for patient DNR status, 38 hospitals had significantly lower than average 30-day readmission rates, and 46 had higher than average 30-day readmission rates. Inclusion of DNR into risk-

standardization models resulted in seven (2.2%) hospitals changing ranking categories: two hospitals labeled as poor performers in the standard model became average hospitals, and five hospitals initially in the better-than-average category became average-performing hospitals (Figure E3).

Sensitivity analyses. In multiple sensitivity analyses, we observed similar findings as in our primary analysis (Tables E4–E7). Inclusion of early DNR status in risk-adjusted readmission models resulted in changes in ranking categories for between two and eight hospitals in sensitivity analyses.

Discussion

Using a large population cohort of patients hospitalized for pneumonia, we investigated the association of admission DNR status

Figure 3. Hospital risk-adjusted 30-day unplanned readmission rates for patients hospitalized for pneumonia. The x-axis intersects the y-axis at 18.5%, the average unadjusted hospital 30-day readmission rate. Error bars indicate 95% confidence interval toward the national average 30-day readmission rate only for hospitals with rates statistically different from the average hospital.

with 30-day readmission rates. We observed lower readmission rates for patients with early DNR orders and lower readmission rates among hospitals admitting a larger

proportion of patients with DNR orders. Interestingly, hospitals with high DNR rates had lower readmission rates among patients with and without DNR orders. Inclusion of

DNR status into hospital readmission quality measures changed 30-day pneumonia readmission ranking categories for a small percentage of hospitals. Our findings were robust to multiple sensitivity analyses.

We are unaware of prior work that has examined the association of patient DNR status and readmissions. We speculate that patients with early DNR orders may be more likely to have an evolution in advanced directives during their hospital stay, opting for do-not-hospitalize, comfort care, or discharge to hospice, potentially leading to a lower risk for readmission. In addition, patients with DNR orders have higher competing risks of 30-day mortality (7). Importantly, CMS does account for patients discharged to hospice in readmission models (14), which may confound current readmission quality rankings, as patients discharged to hospice may be less likely to be readmitted, given preestablished limitations on care. Future studies investigating evolution of advance directives during hospitalization or the association of readmission with advanced directives at the time of discharge may help

Figure 4. Association of hospital risk-adjusted 30-day unplanned readmission rates with hospital risk-adjusted early DNR rates. Quadratic spline regression was used to visualize the relationship. Hospitals with higher early DNR rates had lower 30-day readmission rates for patients hospitalized with pneumonia (Spearman's correlation, $r = -0.44$; $P < 0.0001$). DNR = do not resuscitate.

further inform the relationship between DNR status and readmission.

Our findings can be placed in the context of prior analyses of DNR status in pneumonia hospital quality measures. Despite large changes in hospital quality rankings for pneumonia mortality after adjustment for DNR status (8), we found that only 2.2% of hospitals changed ranking categories with inclusion of early DNR status in readmission models. The larger effect of early DNR status on hospital rankings for mortality than for readmission risk is likely attributable to substantial difference in strengths of association between DNR and mortality (300% increased risk) compared with DNR and readmission (7% reduced risk) (8). Thus, in the setting of similar between-hospital variation in DNR rates, DNR is a strong confounder for mortality rates and a weak confounder for readmission rates. Despite only minimal hospital ranking changes with inclusion of early DNR into California readmission models, different practices around end-of-life care and hospice availability may show different effects on adjusted hospital readmission rates across states and warrant more widespread study.

Despite a weak association between patient-level DNR and readmission, we observed a strong association between hospital DNR rates and lower readmissions. Hospitals with higher DNR rates had lower readmission rates, regardless of individual patient DNR status. The discrepancy in the strength of association with readmission between patient DNR status and hospital DNR rates may stem from the possibility that hospital DNR rate is a marker of unmeasured hospital characteristics or practice patterns that are strongly associated with lower readmissions. Although it is not possible to determine what specific characteristics or practice patterns may account for the lower readmissions observed with higher hospital DNR rates, we speculate that there could be multiple potential contributing factors. Patients with early DNR orders may be more likely to have preestablished outpatient care that led to advance directives.

As such, higher DNR rates may be indicative of a hospital's tendency to admit patients from catchment areas in which patients have broader access and better transitions between inpatient and outpatient care, which could result in lower

readmission rates (21–23) for patients at higher DNR rate hospitals, regardless of DNR status. Alternatively, hospitals that tend to provide more comprehensive education on advanced directives at the time of admission (24) may have higher early DNR rates and may provide greater discharge education, which has been linked to lower readmission rates (25). In addition, multiple studies have shown large between-hospital differences in intensity of end-of-life care and advanced directives that persist even after adjustment for patient-level factors (26–29). Physician and hospital cultural norms that result in higher hospital DNR rates may also signal a greater tendency to transition patients failing treatment, regardless of admission DNR status, to lower intensities of care during hospitalization (e.g., hospice or comfort care) that may be associated with reduced risk for readmission.

Patient factors may also play a role in the association of lower risk for readmission for all patients admitted to high DNR hospitals. Similar to prior work (30, 31), we identified socioeconomic and demographic differences between hospital DNR rate quartiles, with low-income zip code of residence and non-white race associated with low DNR rates and high readmission risks. Residual confounding may be present from patient characteristics associated with DNR and readmission rates that cluster within hospitals, but are unaccounted for by crude measures of regional socioeconomic status such as median income of residence zip code. Further studies are necessary to determine mechanisms linking hospital DNR rates with patients' socioeconomic status.

Limitations

Our study has several limitations. The California State Inpatient Database provided a large diverse population with unique access to early DNR status, but findings may not be generalizable to the rest of the United States. We used previously validated algorithms (13) with high positive predictive values to define index cases of pneumonia, but the use of billing codes may introduce some degree of misclassification bias. However, when we restricted our pneumonia definitions to only patients with a principal diagnosis of pneumonia, we observed similar results to those using the broader definition of

pneumonia. In addition, our risk-standardization models differed from those used by CMS (14) by inclusion of markers of socioeconomic status and markers of severity of acute illness, as well as methods for identifying chronic comorbidities that could affect our observed associations. However, readmission rates in our study were similar to reports in Medicare data (21, 23, 32, 33), and use of risk-adjustment models more similar to CMS did not substantially alter our findings.

In addition, 30-day mortality and 30-day readmissions are competing risks. Although we excluded patients who died in hospital, we could not account for the competing risk for postdischarge death within the 30-day window, which may be more common among patients with DNR orders. Thus, it is likely that our findings underestimate associations between DNR status and readmissions. However, current hospital quality measures, such as the CMS hospital readmission reduction program, similarly do not account for competing risk for death after hospital discharge. We also could not account for DNR orders placed after the first 24 hours, which may be more indicative of severity of illness (34) and may be more strongly associated with readmission.

Conclusions

Hospital health care quality measures are increasing in number, with significant financial implications to hospitals deemed to be underperformers. We observed weak patient-level associations between early DNR status and 30-day unplanned pneumonia readmission and strong associations between hospital early DNR rates and patient and hospital 30-day unplanned pneumonia readmission risk. Strong associations between hospital DNR and readmission rates in the context of weak patient-level associations suggest that hospital DNR rates may account for unmeasured hospital characteristics that are associated with lower readmission risk. Further work is needed to identify links between processes of care for eliciting advance directives and hospital discharge/readmission practices. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

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