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Hospital Variation in Utilization of Life-Sustaining Treatments among Patients with Do Not Resuscitate Orders

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Abstract Word Count: 183/200

Objective: To determine between-hospital variation in interventions provided to patients with DNR orders.

Data Sources/Setting: United States Agency of Healthcare Research and Quality, Healthcare Cost and Utilization Project, California State Inpatient Database

Study Design: Retrospective cohort study including hospitalized patients aged 40 and older with potential indications for invasive treatments: in-hospital cardiac arrest (indication for CPR), acute respiratory failure (mechanical ventilation), acute renal failure (hemodialysis), septic shock (central venous catheterization), and palliative care. Hierarchical logistic regression to determine associations of hospital 'early' DNR rates (DNR order placed within 24 hours of admission) with utilization of invasive interventions.

Data Collection/Extraction Methods: California State Inpatient Database, year 2011.

Principal Findings: Patients with DNR orders at high DNR rate hospitals were less likely to receive invasive mechanical ventilation for acute respiratory failure or hemodialysis for acute renal failure, but more likely to receive palliative care than DNR patients at low DNR rate hospitals. Patients without DNR orders experienced similar rates of invasive interventions regardless of hospital DNR rates.

Conclusions: Hospitals vary widely in the scope of invasive or organ-supporting treatments provided to patients with DNR orders.

Keywords: Administrative data, end of life care, hierarchical regression models, hospice and palliative medicine, patient preference, quality assessment, risk adjustment, utilization, variation

Introduction

Advance directives are meant to foster patient autonomy by documenting wishes regarding life sustaining treatments prior to loss of active decision-making capacity. While efforts to increase the specificity of advance directives have gained traction (e.g., Patient Orders for Life Sustaining Treatment forms)(National POLST), Do Not Resuscitate (DNR) orders remain a common method to document wishes to forgo certain life-sustaining treatments, particularly among patients requiring hospitalization. In the strictest interpretation, DNR orders are meant to convey wishes of patients not to receive cardiopulmonary resuscitation (CPR) during cardiac arrest. In reality, survey studies suggest DNR orders may be broadly interpreted by both patients and physicians(Beach and Morrison 2002; La Puma et al. 1988) to suggest limitation of a wide range of health care interventions (e.g., mechanical ventilation, hemodialysis, invasive procedures).

Between-hospital differences in the rate of DNR orders placed at hospital admission ('early DNR orders') and the procedures or therapies provided to patients with DNR orders may substantially impact patient experiences and outcomes, and may confound evaluations of treatment variation (Bradford et al. 2014) and quality.(Escobar et al. 2013a; Kelly et al. 2014; Tabak et al. 2005; Walkey et al. 2016) Somewhat paradoxically, prior studies demonstrated that patients with DNR orders tended to have higher mortality when admitted to hospitals with low DNR rates.(Escobar et al. 2013b; Tabak et al. 2005; Walkey et al. 2016; Zingmond and Wenger 2005) One potential explanation for this finding is that low DNR rate hospitals may apply DNR orders with more extensive scope of limitations on organ-supportive therapies (e.g., a DNR order implies “no CPR, no mechanical ventilation, no dialysis, and no invasive procedures”) as compared with high DNR rate hospitals (where DNR may only imply “no CPR”). Although variation in the prevalence of DNR orders, mortality rates,(Escobar et al. 2013b; Tabak et al. 2005; Walkey et al. 2016; Zingmond and Wenger 2005) and hospital norms surrounding end-of-life care (Barnato et al. 2007; Barnato et al. 2014) has been previously described, associations between hospital DNR rates and the scope of invasive or organ-supportive therapies provided to patients admitted with DNR orders across hospitals are unclear.

In order to close knowledge gaps regarding variation in the implementation of DNR orders across hospitals, we examined associations of early DNR orders (placed within 24 hours of admission) with utilization of invasive procedures and organ-supportive therapies (such as mechanical ventilation) among patients hospitalized with acute organ failures. Given prior reports of higher mortality rates for patients with DNR orders at low DNR rate hospitals, (Escobar et al. 2013b; Tabak et al. 2005; Walkey et al. 2016; Zingmond and Wenger 2005) we hypothesized that low DNR rate hospitals may apply DNR orders with more extensive scope of limitations on invasive procedures, with lower likelihood of utilizing invasive interventions among patients with DNR orders and indications for each invasive intervention (as compared to DNR patients in high DNR rate hospitals).

Methods

Cohort

We analyzed a population-based cohort of hospitalized adults aged 40 and older abstracted from the 2011 Healthcare Cost and Utilization Project, California State Inpatient Database (CA SID) (Healthcare Cost and Utilization Project, 2011) an administrative claims database containing all non-Federal acute care hospitalizations in California. A characteristic of the CA SID is a validated field that captures DNR orders written during the first 24 hours of hospitalization (‘early DNR’).(Goldman et al. 2013) Using algorithms based upon *International Classification of Diseases*, *9th edition*, *Clinical Modification* (*ICD-9-CM)* codes, we defined 4 non-exclusive cohorts of patients with potential indications for interventions or organ supportive therapies of interest: patients with any diagnosis of acute respiratory failure (to evaluate mechanical ventilation), acute renal failure (hemodialysis), septic shock (central venous catheterization) and cardiac arrest (CPR), (see **Supplemental Digital Appendix Table 1)**. In order to avoid capturing out of hospital cardiac arrest, we excluded patients with cardiac arrest coded as present on admission. However, because mechanical ventilation, dialysis, or central venous catheterization are less likely initiated acutely out of hospital, we did not place restrictions on timing of acute respiratory failure, acute renal failure, or septic shock.

Early DNR Measures

Both patient-level early DNR status and hospital-level early DNR rates were identified. We defined hospital DNR rates as the percentage of patients with an early DNR order among all patients ages 40 and older at each hospital; we excluded severe outlier hospitals with DNR rates less than or greater than the 95%ile (i.e., 0% or more than 25%). Hospital DNR rates among all patients correlated strongly with hospital DNR rates among patients with conditions of interest (r = 0.92).

Covariates

We developed a mortality risk index for comorbidities and acute organ failures among our cohort of hospitalized patients to improve statistical model performance. In separate logistic regression models including Elixhauser (Elixhauser et al. 1998) comorbidities and acute organ failures, we assigned integer values based upon effect estimates for each comorbidity (risk score calculations shown in **Supplemental Digital Content Table 2**) or acute organ failure (**Supplemental Digital Content Table 3**) as a predictor of mortality.(Angus et al. 2001; Martin et al. 2003) Each patient was assigned a comorbidity score from the sum of the comorbidity values and an acute organ failure score from the sum of the organ failure values. We then risk-adjusted models using patient demographics, hospital characteristics, the Elixhauser comorbidity risk index and acute organ failures index (c-statistic for full model to predict mortality among hospitalized cohort=0.88).

Outcomes

We computed risk-standardized hospital rates of invasive or organ-supportive therapies among at-risk patients, including: a) mechanical ventilation during acute respiratory failure, b) hemodialysis during acute renal failure, c) central venous catheterization during septic shock, and d) CPR among patients with in-hospital cardiac arrest. The four different procedures were selected to represent different levels of organ support, "invasiveness" and specificity in conventional DNR orders, ranging from CPR (multi- organ support, more invasive and explicitly limited by a DNR order) to mechanical ventilation and hemodialysis (individual organ support, high-to-moderately invasive, inconsistently limited by DNR orders) to central venous catheters (partial organ support, likely considered less invasive and unlikely to be explicitly limited by a DNR order). We also examined associations of patient DNR status and hospital DNR rates with patient receipt of invasive or organ supporting interventions. As additional measures of resource utilization we examined encounters for palliative care (*ICD-9-CM* V66.7, sensitivity 81%, specificity 97%) (Qureshi, Adil, and Suri 2013) among patients with DNR orders, as well as hospital length of stay (LOS) for patients included in any of the 4 organ failure cohorts.

Statistical Analysis

Summary data were examined across quartiles of hospital DNR rate. We also assessed the distribution of demographics, comorbid conditions, and acute organ failures stratified by individual patient DNR status. In order to assess potential differences in utilization rates by patient DNR status, we stratified analyses examining associations between hospital DNR rates and interventions by patient DNR status. We assessed effect modification by patient DNR status across hospital DNR rate by using a hospital DNR rate by patient DNR status multiplicative interaction term. As previously described,(Walkey et al. 2016) models assessing associations of hospital DNR rates with resource utilization were adjusted for fixed effects of demographics, hospital characteristics, Elixhauser comorbidity index, acute organ failures index, and patient-level DNR status; models also accounted for hospital random intercepts as well as random DNR slope coefficients. Including DNR status as both a fixed effect and a random slope coefficient allowed the association between patient DNR status and resource utilization to vary for each hospital.(Agresti and Hartzel 2000; Finucane, Samet, and Horton 2007; Gould 1998; Localio et al. 2001) We used hierarchical logistic regression to model utilization of interventions and organ supportive therapies with hospital random intercepts. Cox proportional hazards models censored on death and transfer, with robust variance estimators for hospital clustering, were used to model length of stay.

Hospital risk-standardized intervention rates were calculated from the ratio of hospital risk-adjusted rate to the average risk-adjusted rate, multiplied by the average hospital rate in California.(Bratzler et al. 2011) We evaluated the relative contribution of different covariate characteristics (patient DNR status, patient demographics/severity of illness, measured hospital characteristics, and hospital clustering effects) to model prediction for resource utilization by measuring change in Akaike's Information Criterion after exclusion of each characteristic of interest from a fully-adjusted model.(Gershengorn et al. 2014; Harrell 2001) We compared hospital variation in use of invasive and organ supportive therapies among decedents (to reduce confounding by indication)(Fisher et al. 2003; Wiener and Welch 2007) among patients with and without DNR orders using coefficients of variation, calculated as the standard deviation divided by mean hospital DNR rate.(Verrill and Johnson 2007) We visualized variation in utilization among patients with DNR orders with 'caterpillar' plots and evaluation of statistically significant hospital outliers of risk-standardized utilization rates.

In order to further account for potential differences in case-mix severity and *ICD-9-CM* coding differences between hospitals, we calculated the ratio of resource utilization for patients with and without DNR within each hospital. We correlated the within-hospital 'DNR : not DNR' utilization ratio with hospital DNR rates. Hospital-level correlations were assessed quantitatively using Spearman rank correlation coefficients and visually using penalized b-spline regression.(Eilers and Marx 1996)

Sensitivity Analyses

Because eligibility to receive interventions may vary by unmeasured differences in severity of illness that confound relative estimates of resource utilization, we repeated analyses of associations between hospital DNR rates and patient risk for receiving interventions only among patients with DNR orders who did not survive the hospitalization (decedents). We reasoned that decedents in each respective cohort would be the sickest patients (100% mortality) and would thus be more likely to require the intervention of interest, reducing unmeasured confounding by indication.(Fisher et al. 2003; Wiener and Welch 2007) Because age is strongly associated with

DNR status, we also repeated analyses of associations between hospital DNR rates and patient risk for receiving interventions only among patients 80 years of age or older. We performed a third sensitivity analysis excluding patients whose outcomes may be biased by transfer in or out of the hospital, or who had a rehabilitation or ‘convalescence’ *ICD-9-CM* code (V57.86,V66). We used SAS version 9.4 (Cary, NC) and a two-tailed alpha level of 0.05 for all analyses. All procedures were performed on de-identified data and approved by Boston University Medical Center Institutional Review Board as exempt from review.

Results

Hospital and patient characteristics

Among 2.2 million adult admissions in 311 California hospitals reporting patient early DNR orders, we identified 376,793 patients with indications of interest. After excluding outlier hospitals beyond the 95%ile, hospital early DNR rates averaged 7.6% with a range of 0.15% to 25.3% (**Supplemental Digital Content Figure 1**). As expected, patients with DNR orders were older, with more comorbid conditions and acute organ failures (**Supplementary Digital Content Table 4**) and were less likely to receive CPR, invasive mechanical ventilation, hemodialysis, and central venous catheters when compared to patients without DNR orders (**Table 1**).

Table 2 demonstrates patient and hospital characteristics for all 2.2 million adult admissions and for patients with indications of interest, according to hospital DNR rate quartile. Hospitals with the highest DNR rates were less likely to be urban or teaching hospitals, had fewer beds, and were more likely to be not-for-profit than hospitals with low DNR rates. Patients admitted to higher DNR rate hospitals were older, more likely to be white, more likely to have Medicare or private insurance, had higher median household incomes, and greater indices of disease severity as compared to patients admitted to hospitals with low DNR rates. However, among admissions with in-hospital cardiac arrest, acute respiratory failure, acute renal failure and septic shock, patients at high DNR rate hospitals tended to have lower comorbidity and acute organ failure indices.

Variation in treatment utilization among patients with early DNR orders

Among patients with organ failures, early DNR orders explained between 3-10% of model predictive ability for utilization of each intervention (**Supplemental Digital Content Table 5**). Hospital coefficients of variation for intervention rates were significantly greater among patients with DNR orders than patients without DNR orders for mechanical ventilation, hemodialysis, and central venous catheters, but not CPR (**Supplemental Digital Content Table 6**). Variation among hospitals in the proportion of patients with DNR orders who received mechanical ventilation for acute respiratory failure (**Supplemental Digital Content Figure 2A**, 32 outlier hospitals) and central venous catheter for septic shock (**Supplemental Digital Content Figure 2B**) was large when compared with CPR for cardiac arrest [**Supplemental Digital Content Figure 2C**, 2 outlier hospitals] and hemodialysis for acute renal failure [**Supplemental Digital Content Figure 2D**, 0 outlier hospitals].

Hospital DNR rate and treatment variation

Patients without DNR orders admitted to high DNR rate hospitals did not have significantly different rates of CPR, mechanical ventilation, or hemodialysis than patients without DNR orders at low DNR hospitals; rates of central venous catheters were higher for patients without DNR orders at high DNR rate hospitals (**Table 3**). In contrast, patients with DNR orders admitted to high DNR rate hospitals were significantly less likely to receive invasive mechanical ventilation [multivariable-adjusted odds ratio (aOR) DNR quartile 4 vs quartile 1: 0.59, (95% CI 0.45-0.76)] or hemodialysis [aOR 0.58 (95% CI 0.41-0.84)] than patients with DNR orders at low DNR rate hospitals (**Table 3**). Associations between hospital DNR rates and use of mechanical ventilation, hemodialysis, and central venous catheters differed based upon patient DNR status ($p_{interaction}$ <0.01, **Table 3**). The within-hospital ratio of intervention rates for patients with DNR vs. without DNR orders was inversely correlated with hospital DNR rates for mechanical ventilation (r = -0.19, p=0.001, **Figure 1a**) and central venous catheters (r = -0.17, p=0.004, **Figure 1b**), but not CPR (-0.04, p=0.52) or hemodialysis (r= -0.07, p=0.24).

Among patients with DNR orders, 13193/52864 (25%) had a palliative care encounter. Hospitals with higher early DNR rates were more likely to utilize palliative care for patients with DNR orders (DNR rate quartile 4 vs. quartile 1 aOR 1.62, 95% CI 1.08-2.45). Compared with lowest quartile DNR rate hospitals, highest quartile DNR rate hospitals had shorter LOS [15% relative reduction in LOS (95% CI 7, 23%].

Sensitivity analyses

Sensitivity analyses evaluating decedents with DNR orders showed similar results as primary analyses, with lower utilization of mechanical ventilation (aOR 0.69, 95% CI 0.53-0.90) and hemodialysis (0.52, 95% CI 0.33-0.81), and similar rates of CPR (aOR 0.83, 95% CI 0.54-1.30) and CVL (aOR 1.00 95% CI 0.85-1.49) in highest DNR rate quartile hospitals. Exclusion of patients with rehabilitation diagnosis codes, transfers in or transfers out to other acute care hospitals (**Supplemental Digital Content Table 7**) or restriction to patients aged 80 years or older (**Supplemental Digital Content Table 8**) also did not substantively change results.

Discussion

We explored variation among hospitals in invasive and organ supportive interventions (e.g., mechanical ventilation during acute respiratory failure) provided to patients with early DNR orders. Rates of invasive and organ supportive therapies among patients with DNR orders varied greatly between hospitals. Hospitals with high DNR rates tended to use fewer organ support therapies and more palliative care for patients with DNR orders, but use of organ support interventions did not markedly differ by hospital DNR rates among patients without DNR orders. For example, a theoretical patient with acute respiratory failure without a DNR order would be equally likely to receive mechanical ventilation at a high or low DNR rate hospital, but a patient with a DNR order would be nearly half as likely to receive mechanical ventilation depending on the DNR rate of the hospital to which they were admitted. Our findings suggest that patients with DNR orders may have considerably different experiences depending upon the hospital to which they are admitted, with ramifications for the reporting of hospital practices around wishes for life-sustaining treatments, measurement of practice variation and hospital quality.

Few prior studies have examined associations between DNR orders early in the course of hospitalization and resource utilization. Similar to our findings, Hart et al. identified wide variation in treatment limitations among 13405 patients with pre-existing DNR orders admitted to intensive care units included in the Project Impact database (Hart et al. 2015) and observed that a large proportion (23%) of patients with orders for treatment limitation also received CPR.

Potential explanations of higher-than-expected CPR rates among patients with DNR orders include a clinician ignoring or patient/surrogate reversal of DNR orders, CPR performed prior to DNR decisions, or higher rates of misclassification for CPR than other *ICD-9-CM* procedure codes. Our findings among hospitalized patients with acute organ failures extend those of Hart et al., using patients without DNR orders as a control for between-hospital variation in case mix, eliminating selection bias that may be due to hospital variation in intensive care unit admission among patients with DNR orders, and examining use of palliative care. Our findings differed from Hemphill et al. (Hemphill et al. 2004), who showed that high hospital DNR rates among patients with intracerebral hemorrhage were associated with a general 'nonaggressive approach', regardless of individual patient DNR status. Rather than a general 'nonaggressive approach' at higher DNR rate hospitals, measured indices of 'aggressiveness' were similar (or greater) among patients without DNR orders at hospitals with high DNR rates.

Importantly, we found that hospitals with higher DNR rates tended to use a less invasive, more palliative approach among patients with DNR orders. The observation that utilization of organ-supportive interventions was lower for patients with DNR orders at high DNR rate hospitals was contrary to our hypothesis that higher DNR rate hospitals would tend to use DNR orders with less extensive limitations on care. This makes it unlikely that previously described inverse associations between hospital DNR rates and hospital mortality among patients with DNR orders (Tabak et al. 2005) are explained by greater willingness to use invasive therapies to 'rescue' patients with pre-existing DNR orders (e.g., a patient with respiratory failure requiring mechanical ventilation) at higher DNR rate hospitals.

Based on our findings showing minimal variation between hospitals in use of CPR among patients with DNR orders, as well as similar odds of receiving CPR for cardiac arrest regardless of underlying hospital DNR rate, the strictest definition of DNR ("no CPR") did not substantially vary between hospitals. However, organ-replacement therapies that may not fall under 'strict' definitions of DNR such as mechanical ventilation (i.e., 'Do Not Intubate' orders) and dialysis were less likely to be used among DNR patients at hospitals with higher rates of DNR orders. Further, when compared to hospitals with low DNR rates, hospitals with high DNR rates used fewer central venous catheters and less mechanical ventilation among patients with DNR orders than patients without DNR orders. Our findings are in accordance with previous survey studies that demonstrated potentially wide physician-level variation in application of DNR orders.(Beach and Morrison 2002; Garland and Connors 2007; La Puma et al. 1988) However, our results extend prior physician survey results to real-world practice, and suggest that the scope of interventions provided to patients with DNR orders depends on the hospital to which they were admitted.

Fewer invasive interventions among patients with DNR orders at high DNR rate hospitals potentially signal different hospital practices and local cultural norms (Barnato et al. 2007; Barnato et al. 2012; Cutler et al. 2015; Dzeng et al. 2015; Halpern et al. 2013) for discussing, eliciting, and documenting patient wishes regarding life sustaining treatments. Lower comorbidity and acute organ failure indices observed at high DNR rate hospitals also suggest that hospitals vary in the thresholds at which invasive interventions may be limited. Although we were unable to access details of physician-patient/surrogate discussions regarding decisions to limit life support interventions and were unable to address the extent to which limits were based upon patient-driven, physician-driven or shared decisions, survey-based studies show that healthcare utilization at the end-of-life may be more strongly associated with local physician practice style than patient beliefs.(Barnato et al. 2007; Barnato et al. 2012; Cutler et al. 2015) Our findings suggest that studies should continue to explore how interactions between patient beliefs and physician practice styles drive measured variation in hospital DNR rates and the scope of therapies associated with DNR orders. Further efforts to standardize documentation and increase the specificity of patient advance directives (National POST) may better align patient wishes with care received,(Chen et al. 2014) potentially reducing the influence of individual physician beliefs or local hospital norms.

Because variation in healthcare utilization was partly explained by variation in preferences for life-sustaining treatments, our results support identification of patient wishes to withhold life-sustaining therapies in programs that seek to evaluate healthcare quality. For example, accurate measurement and description of the variation in DNR practices between hospitals would produce greater transparency in public reporting of hospital practices and potentially allow patients to choose hospitals with practice patterns that best align with their beliefs. Although wide variation in DNR rates and DNR scope between hospitals complicates evaluation of healthcare delivery,(Tabak et al. 2005; Walkey et al. 2016) the lack of substantial differences in interventions used among patients without DNR orders supports strategies that assess robustness of quality rankings after adjusting for or excluding patients with early DNR orders.(California Office of Statewide Health Planning and Development) However, given that many patients with DNR orders received organ supportive therapies – potentially indicating a commitment to full support short of CPR – methods that better account for variation in scope of DNR orders between hospitals should be further developed to compare patient outcomes (Walkey et al. 2016).

Our study has potential limitations. The early DNR variable of CA SID shows ~85% accuracy (Goldman et al. 2013); differential misclassification of DNR orders may affect our findings. DNR orders placed after the first day of hospitalization were unavailable in the CA SID dataset, but are generally correlated with failure to respond to treatments, rather than pre-existing wishes regarding life support and invasive treatments.(Marrie et al. 2002) Because patients at high DNR rate hospitals had shorter LOS, further studies seeking to explore differences in hospital mortality among patients with DNR orders should explore 30-day mortality rates or whether patients with DNR orders at high DNR rate hospitals are more likely to transfer to hospice care, information unavailable through the CA SID. In addition, unmeasured differences in severity of illness may potentially explain variation in invasive treatments based upon hospital DNR rates. However, several lines of evidence argue against strong unmeasured confounding by severity of illness. First, our covariate adjustment produced models with high resolution for predicting mortality outcomes, reducing likelihood of confounding by severity of illness.(Sjoding et al. 2015) Second, our results were similar in analyses including only decedents, with likely severe illness.(Fisher et al. 2003; Wiener and Welch 2007) Third, we did not find lower utilization of interventions according to hospital DNR rates among patients without DNR orders. Fourth, within-hospital analyses that would better control for differences in case mix also showed greater reduction in utilization of some invasive procedures among patients with DNR orders at high DNR rate hospitals.

In conclusion, hospital variation in the scope of decisions to limit life sustaining treatments contributed to differences in healthcare utilization. Hospitals with higher DNR rates tended to have broader limits on life-support interventions and greater use of palliative care among patients with DNR orders than hospitals with low DNR rates. Variation in the scope of DNR orders between hospitals has broad ramifications, from types of care delivered to patients, to the need for accurate reporting of healthcare delivery to patients and policymakers. Improved efforts to measure and report hospital practices regarding decisions to limit life-sustaining treatments are warranted.

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Figure Captions

Figures 1a and 1b. Association of hospital ratio of utilization between patients with and without DNR orders to hospital DNR rate for mechanical ventilation (1a) and central venous catheters (1b).

Table 1. Interventions for patients with and without early DNR orders

Intervention	**% given intervention**		**DNR vs. no DNR Adjusted odds ratio (95% CI)**
	Patients with DNR Order	**Patients with No DNR Order**	
CPR, among in-hospital cardiac arrest N= 8581	32%	54%	0.39 (0.34-0.45)
Invasive mechanical ventilation, among acute respiratory failure N= 162723	31%	46%	0.56 (0.53-0.61)
Hemodialysis, among acute renal failure N= 260768	4.3%	8.1%	0.57 (0.52-0.62)
Central venous catheter, among septic shock, N= 43927	40%	49%	0.65 (0.61-0.70)

Model adjusted for age, sex, race, payor, median income for residence zip code, comorbidity index, acute organ failure index, hospital urban/rural location, hospital control (eg., not-for-profit, for profit), hospital teaching status, and number of licensed hospital beds.

Table 2. Patient and hospital characteristics by hospital do not resuscitate quartile				
	Quartile 1 **< 2.5%**	**Quartile2** **2.5-6.2%**	**Quartile 3** **6.2-10.6%**	**Quartile 4** **>10.6%**
All Patients	N=488,964	N=643,369	N=596,881	N=491,569
Age	64.4 ± 14.2	65.5 ± 14.5	67.5 ± 14.5	68.0 ± 14.5
Comorbidity Index	16.6 ± 22.9	17.5 ± 23.0	18.1 ± 23.5	18.3 ± 23.5
Acute organ failure Index	0.88 ± 2.22	0.94 ± 2.3	0.94 ± 2.3	0.96 ± 2.2
Sex, female	52%	53%	54%	54%
Race, White	43%	54%	62%	71%
Insurance				
Medicare	50%	52%	58%	60%
Medicaid	20%	16%	10%	7%
Private	18%	22%	20%	28%
Highest income quartile	11%	23%	24%	29%
Hospital Characteristics				
Teaching hospital	27%	32%	4%	7%
Not-for-profit	53%	56%	74%	88%
Urban	95%	95%	92%	89%
Licensed Beds	373 ± 219	361 ± 172	316 ± 135	274 ± 125
In-hospital Cardiac Arrest	**N=2083**	**N=2743**	**N=2403**	**N=1662**
Age	70.0 ± 13.4	70.0 ± 13.4	71.7 ± 13.2	71.7 ± 13.7

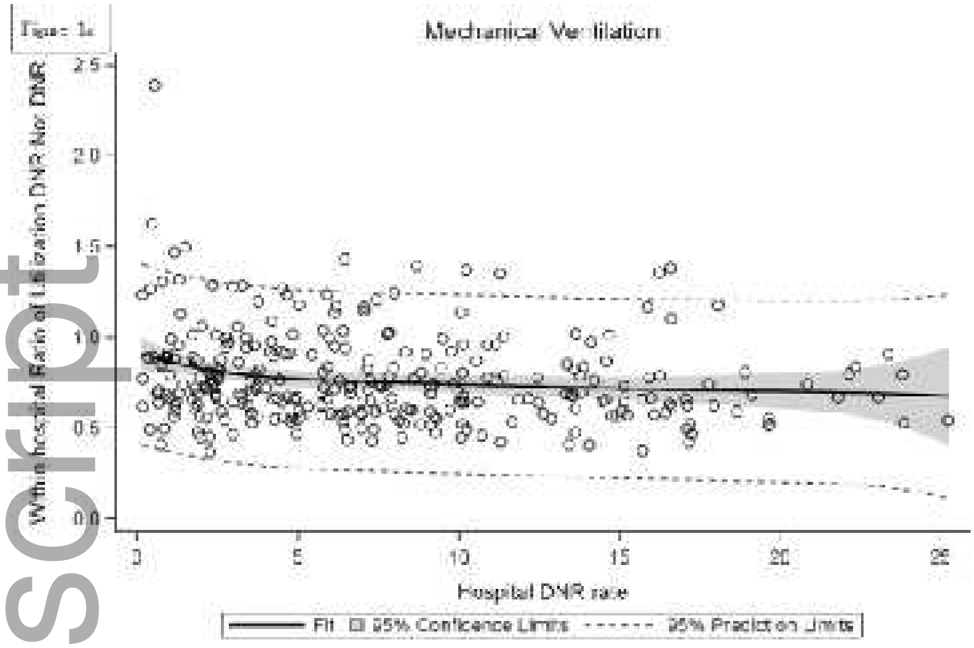
Comorbidity Index	43.5 ± 29.8	42.2 ± 29.0	41.3 ± 29.3	39.2 ± 28.5
Acute organ failure index	3.9 ± 4.7	3.4 ± 4.5	3.2 ± 4.3	3.0 ± 4.1
Acute respiratory failure	**N=31714**	**N=47539**	**N=45794**	**N=37704**
Age	69.2 ± 13.6	69.4 ± 13.9	71.1 ± 13.4	70.9 ± 13.4
Comorbidity Index	38.3 ± 28.9	37.0 ± 27.7	36.4 ± 27.8	35.0 ± 27.7
Acute organ failure index	6.5 ± 4.2	6.5 ± 4.2	6.3 ± 3.9	6.3 ±3.8
Acute renal failure	**N=55041**	**N=79611**	**N=70367**	**N=55786**
Age	70.6 ± 13.9	72.5 ± 13.4	72.6 ± 13.4	73.0 ± 13.4
Comorbidity Index	35.1 ± 26.5	36.4 ± 26.6	36.3 ± 26.7	35.7 ± 26.7
Acute organ failure index	4.0 ± 3.6	3.9 ± 3.5	3.9 ± 3.5	4.0 ± 3.4
Septic shock	**N=9435**	**N=14078**	**N=11435**	**N=8981**
Age	69.5 ± 13.6	69.6 ± 13.5	71.0 ± 13.4	70.9 ± 13.5
Comorbidity Index	49.3 ± 29.4	47.5 ± 28.3	46.9 ± 28.9	45.2 ± 28.8
Acute organ failure index	8.6 ± 5.2	8.7 ± 5.1	8.4 ± 5.0	8.3 ± 4.8

Table 3. Interventions for patients admitted to high vs. low DNR rate hospitals according to patient DNR status

Intervention		**Comparison of odds ratios:**

	Adjusted Odds Ratio (95% CI) of Receiving Intervention, Hospital DNR Rate Quartile 4 (high) vs. Quartile 1 (low)		Hospital DNR rate and intervention, DNR vs. No DNR patients
	Patients with DNR Order	**Patients with No DNR Order**	**P, interaction**
CPR, among in-hospital cardiac arrest	1.02 (0.58-1.81) N=1374	1.34 (0.92-1.96) N=7207	0.39
Invasive mechanical ventilation, among acute respiratory failure	0.59 (0.45-0.76) N=24,609	0.95 (0.78-1.16) N=130,134	<0.001
Hemodialysis, among acute renal failure	0.58 (0.41-0.84) N=33,100	0.86 (0.70-1.05) N= 218,964	0.003
Central venous catheter, among septic shock	1.11 (0.78-1.58) N= 7,496	1.72 (1.27-2.32) N= 34,837	<.0001

Model adjusted for age, sex, race, payor, median income for residence zip code, comorbidity index, acute organ failure index, hospital urban/rural location, hospital control (eg., not-for-profit, for profit), hospital teaching status, and number of licensed hospital beds.



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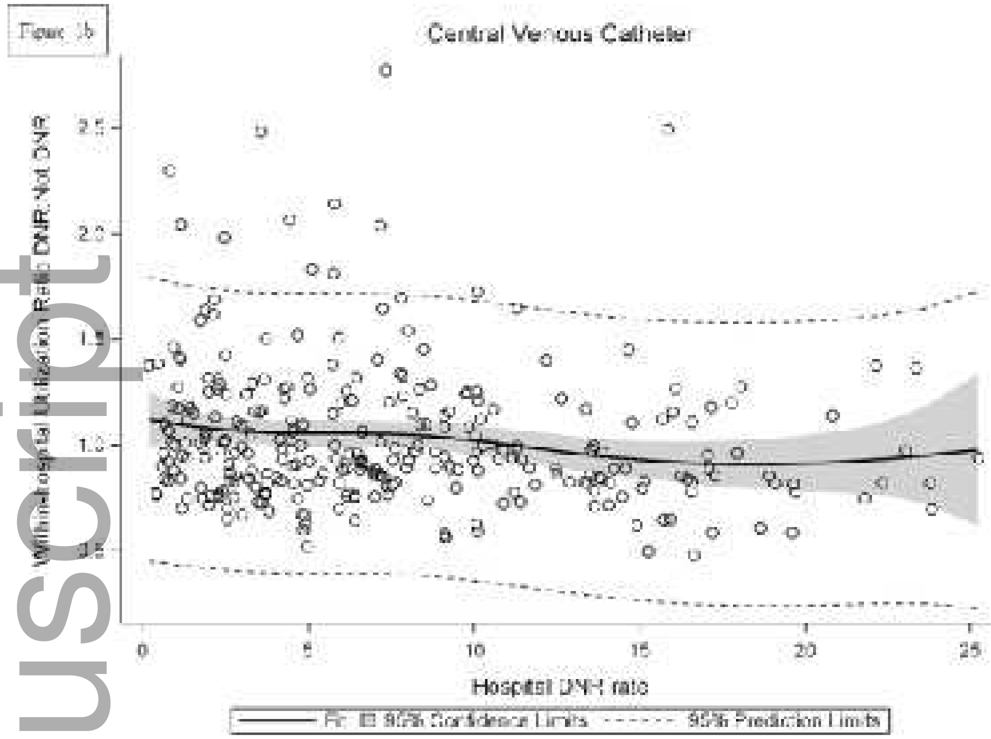

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