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Hospital Variation in Non-Invasive Positive Pressure Ventilation for Acute Decompensated Heart Failure

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Abstract

Background—Although non-invasive positive pressure ventilation (NIPPV) for patients with acute decompensated heart failure (ADHF) was introduced almost 20 years ago, the variation in its use among hospitals remains unknown. We sought to define hospital practice patterns of NIPPV use for ADHF and their relationship with intubation and mortality.

Methods and Results—We conducted a cross-sectional study using a database maintained by Premier, Inc., that includes a date-stamped log of all billed items for hospitalizations at over 400 hospitals. We examined hospitalizations for ADHF in this database from 2005–2010 and included hospitals with annual average volume of greater than 25 such hospitalizations. We identified 384 hospitals that encompassed 524,430 hospitalizations (median annual average volume: 206). We used hierarchical logistic regression models to calculate hospital-level outcomes: risk-standardized NIPPV rate (RS-NIPPV), risk-standardized intubation rate (RSIR), and in-hospital risk-

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Disclosures

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standardized mortality rate (RSMR). We grouped hospitals into quartiles by RS-NIPPV and compared RSMRs and RSIRs across quartiles. Median RS-NIPPV was 6.2% (interquartile range, 2.8–9.3%; 5th percentile, 0.2%; 95th percentile, 14.8%). There was no clear pattern of RSMRs across quartiles. The bottom quartile of hospitals had higher RSIR (11.4%) than each of the other quartiles (9.0%, 9.7%, and 9.1%; $P<0.02$ for all comparisons).

Conclusion—Substantial variation exists among hospitals in the use of NIPPV for ADHF without evidence for differences in mortality. There may be a threshold effect in relation to intubation rates, with the lowest utilizers of NIPPV having higher intubation rates.

Keywords

heart failure; mortality; ventilation

For almost 2 decades, physicians have used non-invasive positive pressure ventilation (NIPPV) in acute decompensated heart failure (ADHF), but its role remains unclear. Prior studies have been limited to the subset of patients with ADHF with acute cardiogenic pulmonary edema and have produced conflicting results.[1–3] No studies have examined the role of NIPPV in a broad cohort of ADHF patients. Moreover, professional societies have disparate guideline recommendations regarding the use of NIPPV in patients with ADHF.[4–7]

In the face of tepid supporting evidence and a lack of professional consensus, understanding how hospitals have adopted NIPPV in treating patients with ADHF can help provide insight into the effectiveness of this therapy. Furthermore, investigating the relationship between the institutional use of NIPPV and hospital outcomes may highlight missed treatment opportunities. In particular, if hospitals that use NIPPV frequently have better outcomes compared with hospitals that do not, low-use hospitals might benefit from increasing their use of NIPPV in certain patients with ADHF. Therefore, in order to characterize hospital practice patterns and their relationship with hospital outcomes, we assessed the hospital variation in NIPPV use for patients with ADHF, the associations between NIPPV use and hospital characteristics, and the association between NIPPV use and hospital-level intubation rates and mortality rates for patients with ADHF.

Methods

Data Source

We conducted a retrospective study using a voluntary, fee-supported database developed by Premier, Inc. for measuring quality and health care utilization. As of 2011, this database contained more than 130 million cumulative hospital discharges from hospitals across the United States. Inpatient discharges in this database represent about 20% of all acute care inpatient hospitalizations nationwide. In addition to the information available in the standard hospital discharge file, this database contains a date-stamped log of all billed items at the hospitalization level, including medications and laboratory, diagnostic, and therapeutic services.

For this study, patient data were de-identified in accordance with the Health Insurance Portability and Accountability Act, and random, unique patient and hospital identifiers were

applied to each record to facilitate analysis. The Yale University Human Investigation Committee exempted this study protocol from review by the Office of Human Research Protections.

Study Cohort

We constructed a cohort of hospitalizations between January 1, 2005, and December 31, 2010, that had a principal discharge diagnosis of heart failure (*International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes 402.01, 402.11, 402.91,404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32,428.33, 428.40, 428.41, 428.42, 428.43, and 428.9) or a principal diagnosis of acute respiratory failure (*ICD-9-CM* code 518.81) combined with a secondary diagnosis of heart failure. A patient could contribute multiple hospitalizations to the cohort.

We excluded patients who were younger than 18 years of age at the time of admission or transferred to or from another acute care facility. We also excluded patients with a secondary diagnosis of obstructive sleep apnea (*ICD-9-CM* codes 327.2, 327.2x, 780.51, 780.53, and 780.57) because we felt it would not be feasible to determine whether NIPPV was administered for ADHF in these patients. We excluded all hospitalizations with a length of stay (LOS) of 1 or 2 days to ensure that each hospitalization in our cohort was at least 24 hours in duration, because we felt that admissions shorter than 24 hours did not likely represent true ADHF and their inclusion would reduce the specificity of our findings. At the institutional level, we excluded hospitals with an annual average of <25 qualifying hospitalizations over the 2005–2010 period in order to produce more stable estimates of hospital outcomes.

Independent Variables

For each hospitalization, in addition to age, sex, race and insurance status, we used the software (versions 3.0, 3.1, 3.2, 3.3, 3.4, 3.5 for federal fiscal years 2005, 2006, 2007, 2008, 2009, 2010, respectively) provided by the Healthcare Costs and Utilization Project of the Agency for Healthcare Research and Quality to classify comorbidities from the standard hospital discharge file based on methods described by Elixhauser.[8] This tool provides a Diagnosis Related Group screen of *ICD-9-CM* secondary diagnoses.

At the hospital level, we included bed count, teaching status, geographic location, and urban/rural status, based on information collected from the American Hospital Association database. In addition, we created the following 4 hospital characteristics based on our cohort. First, yearly average volume of patients with ADHF at each hospital was defined as the total number of discharges in the standard ADHF inpatient cohort for 2005–2010 divided by the total number of years that the hospital was in the database. Second, fraction of patients with a cardiologist as attending physician at each hospital was defined as the fraction of patients in the study cohort for whom the attending physician's specialty was cardiology. Third, cardiovascular procedure rate at each hospital was defined as the number of patients with ADHF receiving any of a predefined group of 228 cardiovascular procedures divided by the number of patients in the study cohort at that hospital. This group

of procedures contains a wide variety of invasive cardiovascular procedures and surgeries (including percutaneous coronary intervention (PCI), coronary artery bypass graft surgery (CABG), and valve replacements) and has been previously used as a means of comparing hospital-level procedural intensity in treating patients with ADHF.[9] Fourth, intensive care unit (ICU) admission rate at each hospital was defined as the number of patients with ADHF admitted to an ICU divided by the number of patients in the study cohort at that hospital.

Outcomes

Our main outcome was hospital-level use of primary NIPPV. In order to calculate this, we first determined the patient-level use of primary NIPPV at each institution. We defined NIPPV as having a standard charge code for either continuous positive airway pressure (CPAP) or bi-level positive airway pressure (BLPAP), and we defined primary NIPPV by 2 criteria: (1) NIPPV on hospital day 1 or 2, and (2) NIPPV without mechanical ventilation on a prior hospital day. We considered NIPPV on the same day as mechanical ventilation to be primary NIPPV provided that both therapies were given on hospital day 1 or 2. We felt that, so early in hospitalization, patients most likely received NIPPV first and were then intubated. Additional outcomes included in-hospital death, intubation, and LOS, defined as the number of calendar days spent in the hospital, inclusive of first and last.

Statistical Analysis

We used the patient-level data to calculate our hospital-level outcomes. First, we employed a hierarchical logistic regression model (HLRM) to estimate risk-standardized NIPPV rate (RS-NIPPV) for each hospital. This approach takes into account the hierarchical structure of the data to adjust for differences in case-mix among hospitals.[10, 11] We considered patient age, gender, Elixhauser comorbidities as initial adjustment variables, and we fitted a logistic model to select the variables for the final model using a stepwise algorithm. In order to ensure that the magnitudes of the unadjusted NIPPV rates and RS-NIPPVs were comparable, we fit a volume-weighted linear regression model between the unadjusted rates and the adjusted rates, and then scaled the values for RS-NIPPV by the inverse of the slope of that regression. We then used HLRM to calculate in-hospital risk-standardized mortality rate (RSMR) and risk-standardized intubation rate (RSIR) for each hospital. For patients contributing multiple hospitalizations to the cohort, we used only a single randomly chosen hospitalization to calculate RSMR. We also determined each hospital's median LOS.

We calculated summary statistics by using frequencies and percentages for categorical data and means, medians, and interquartile ranges (IQRs) for continuous variables. We used Kruskal-Wallis tests to examine relationships between RS-NIPPV and hospital characteristics. We then grouped the hospitals into quartiles by RS-NIPPV and compared RSMRs, RSIRs, and median LOS across quartiles using Kruskal-Wallis tests. Finally, we performed *post hoc* pairwise comparisons using Kruksal-Wallis tests with the Bonferroni correction (Supplement). To apply this correction, we calculated an adjusted *P* value for each comparison by multiplying the unadjusted *P* value by 6 (if this result was > 1, we replaced it with 1).

Statistical significance was set at $P<0.05$. All analyses were done with SAS version 9.3 (SAS Institute, Inc.) statistical software. Procedure GLIMMIX was used to estimate HLRM.

Results

Patient and Hospital Characteristics

We identified 813,783 hospitalizations for ADHF from 2005 to 2010. We excluded 289,353 hospitalizations—192,601 with fewer than 3 service days, 45,262 that were transfers in or out, 81,924 with obstructive sleep apnea, and 1,050 that occurred in the hospitals with fewer than 25 such annual admissions—leaving our final cohort with 524,430 hospitalizations (Figure 1). Median age was 77 years and 241,255 (46%) of hospitalizations were men. The 5 most common comorbidities were hypertension (66%), coronary atherosclerosis (58%), history of ventricular tachycardia or ventricular fibrillation (50%), cardiac dysrhythmias (50%), and chronic obstructive pulmonary disease (COPD) (40%). Table 1 contains detailed patient-level demographic and comorbidity data for the overall study cohort.

Hospitalizations were distributed among 384 hospitals. Median (IQR) bed size was 273 (144–409), and median (IQR) yearly average volume of patients with ADHF was 206 (99–362). At the hospital-level, median (IQR) patient age was 78 years (75–81), and a median (IQR) of 45% (41–48%) of hospitalizations were men. Among the hospitals, 162 (42%) were located in the South, 105 (27%) were teaching, and 306 (80%) served urban populations (Table 2). Median (IQR) fraction of patients with a cardiologist as attending physician, cardiovascular procedure rate, and ICU admission rate were 8% (1–20%), 9% (3–14%), and 22% (17–30%), respectively.

Distribution of RS-NIPPV among Hospitals

We found a wide distribution of RS-NIPPV across hospitals. The median (IQR) was 6.2% (2.8–9.3%), and hospitals ranged from 0.2% at the 5th percentile to 14.8% at the 95th percentile (Figure 2). A substantial proportion of hospitals (n=52, 14%) had RS-NIPPV less than 1%. On the other hand, nearly 5% of hospitals had RS-NIPPV greater than 15%. We found no significant relationship between RS-NIPPV and any hospital characteristic (Table 2).

Hospital Outcomes by Quartile of RS-NIPPV

After grouping hospitals into quartiles by RS-NIPPV, quartiles 1, 2, 3, and 4 had median (IQR) RS-NIPPV of 0.9% (0.3–1.9%), 4.5% (3.6–5.6%), 7.4% (6.8–8.3%), and 11.6% (10.1–14.3%), respectively (Table 3). Patient-level characteristics across different quartiles are shown in Table 1.

RSMRs—Median (IQR) RSMR among all hospitals was 5.5% (4.7–6.4%). We found a significant difference in RSMRs across quartiles of RS-NIPPV ($P=0.0315$) (Table 3). In *post hoc* analysis, the only significant pairwise comparison was between quartile 3 (median RSMR, 5.6%) and quartile 4 (median RSMR, 5.2%; adjusted $P=0.0438$) (Table 4).

RSIRs—Median (IQR) RSIR among all hospitals was 9.8% (7.4%-12.1%). We found a significant difference in RSIRs across quartiles ($P<0.0001$) (Table 3). In *post hoc* pairwise comparisons, quartile 1 (median RSIR, 11.4%) was significantly higher than quartiles 2–4 (median RSIRs, 9.0%, 9.7%, and 9.1%, and adjusted $P=0.0012$, 0.0198, and 0.0006, for quartiles 2, 3, and 4, respectively), but quartiles 2–4 were not significantly different from one another (Table 4).

Median LOS—Median (IQR) LOS among all hospitals was 5 (5–6) days, (Table 3), and we found no significant differences across quartiles in median LOS ($P=0.11$), or in any *post hoc* pairwise comparison (Table 4).

Discussion

We found substantial variation across hospitals in the use of primary NIPPV in patients with ADHF. Although median RS-NIPPV was 6.2%, nearly 14% of hospitals had risk-standardized rates lower than 1%, and nearly 5% of hospitals had risk-standardized rates higher than 15%. Moreover, although we found no clear pattern of associations between RS-NIPPV and RSMR or median LOS, we found that the bottom quartile of hospitals by RS-NIPPV had significantly higher RSIRs than other quartiles. These results suggest that the lowest-use hospitals may be able to reduce the need for intubation in some patients with ADHF without increasing mortality by using NIPPV more frequently, but that otherwise we could not detect a benefit of higher rates.

Although heart failure is highly prevalent[12] and ADHF hospitalizations are very common,[13] patients with ADHF present heterogeneously and may therefore require heterogeneous treatment.[7] Our results demonstrate that heterogeneity in treatment for ADHF also exists among hospitals, even after accounting for differences in case-mix. These results are consistent with prior findings demonstrating that hospital practice patterns in treating acute cardiovascular conditions can vary significantly even after risk-adjustment for patient characteristics.[14, 15] However, we found no correlation between any measured hospital characteristic and NIPPV use. These included institutional characteristics (teaching status, number of beds, urban/rural status) as well as condition-specific characteristics (yearly average volume of patients, cardiovascular procedure rate, ICU admission rate, fraction of patients with a cardiologist as attending physician). These findings suggest not only that NIPPV use for patients with ADHF varies widely across hospitals, but also that practice patterns for this therapy may not parallel patterns of intensity for other cardiovascular procedures such as PCI and CABG.[9] The lack of randomized controlled trials for NIPPV in ADHF may partially explain this difference in utilization of NIPPV relative to other cardiovascular procedures, which have a stronger evidence base. Alternatively, hospital-level factors—such as the presence of respiratory therapists, the number of NIPPV devices available, and the existence of hospital protocols regarding management of respiratory failure—may play the dominant role in determining which hospitals use NIPPV frequently.

Furthermore, there may be clinical consequences associated with hospital variation in NIPPV use. Although we found no clear pattern of RSMRs across quartiles of NIPPV use, we found that hospitals in the lowest quartile had higher RSIRs than hospitals in all other

quartiles. These results suggest that there may be a threshold effect between institutional NIPPV use and intubation for patients with ADHF, such that there is little marginal benefit with increasing use of NIPPV beyond a fairly low point. Nevertheless, given that intubation and mechanical ventilation may cause a myriad of potential complications—including laryngeal injury, ventilator-associated pneumonia, and post-traumatic stress disorder—some patients with ADHF may benefit from greater use of NIPPV among hospitals that are currently in the lowest quartile of use. Randomized controlled trials are needed to evaluate the potential benefits of NIPPV in a broad cohort of patients with ADHF, in particular the potential for avoiding intubation.

Our findings should be interpreted in the context of several limitations. First, our risk adjustment only involved the use of administrative data containing patient demographic characteristics and comorbidities due to a lack of clinical information. However, prior studies have validated the use of such administrative data in risk-adjustment for patients with ADHF[16–18] and in comparing rates of hospital mortality for heart failure.[11] Second, because the log of billed items is stamped only with the date, for patients who received NIPPV and intubation on the same day, we could not definitively determine which therapy occurred first. Nevertheless, in the first 2 days of hospitalization, we considered this to be primary NIPPV because we believe that it is more likely that patients who received both therapies received NIPPV first. Third, despite risk-adjustment, there may be unmeasured confounders at the patient-level or hospital-level. Fourth, although the database we used represents a large and diverse sample of hospitals from across the country, all included hospitals participate voluntarily. Accordingly, our findings may not be generalizable to all hospitals nationwide due to unobserved differences between hospitals in the database and hospitals not in the database. Fifth, approximately 40% of patients in our cohort had COPD, and because some patients with COPD also receive NIPPV, it might be difficult to determine the reason for NIPPV in these patients. Nevertheless, we chose to include these patients in our cohort because only 4.5% of patients admitted with an acute COPD exacerbation receive NIPPV,[19] and because COPD is such a common concomitant condition (31% in the Acute Decompensated Heart Failure National Registry)[20] that omitting these patients would exclude an important subset of the heart failure population. Sixth, we made no attempt to differentiate CPAP and BLPAP. It is possible that CPAP may be more efficacious than BLPAP in patients with ADHF,[21] and if so, some of the variation in practice patterns of NIPPV may reflect differential use of these 2 modalities. Seventh, we did not distinguish heart failure with preserved ejection fraction (HFpEF) from heart failure with reduced ejection fraction (HFrEF). If hospitals have substantially different case-mixes regarding these 2 phenotypes, and if NIPPV is used more commonly in a particular phenotype, our hierarchical models may not have been adequately adjusted. However, our models included age, gender, and comorbidities, all of which have been shown to differ between HFpEF and HFrEF.[22] Finally, we were only able to study outcomes occurring during hospitalization, and it possible that longer-term hospital outcomes (such as 30-day mortality rate or 30-day readmissions rate) may also relate to NIPPV use.

In conclusion, we found that substantial variation exists among hospitals in the use of primary NIPPV in the treatment of ADHF, and that practice patterns for this therapy may not correspond with patterns of intensity for other cardiovascular procedures. Furthermore,

hospitals in the lowest quartile of NIPPV use had higher intubation rates than other hospitals. Although clinical trials will be required to further elucidate the relationship between NIPPV and intubation, these results suggest that some hospitals may be able to reduce intubations without increasing mortality by increasing the use of NIPPV in certain patients with ADHF.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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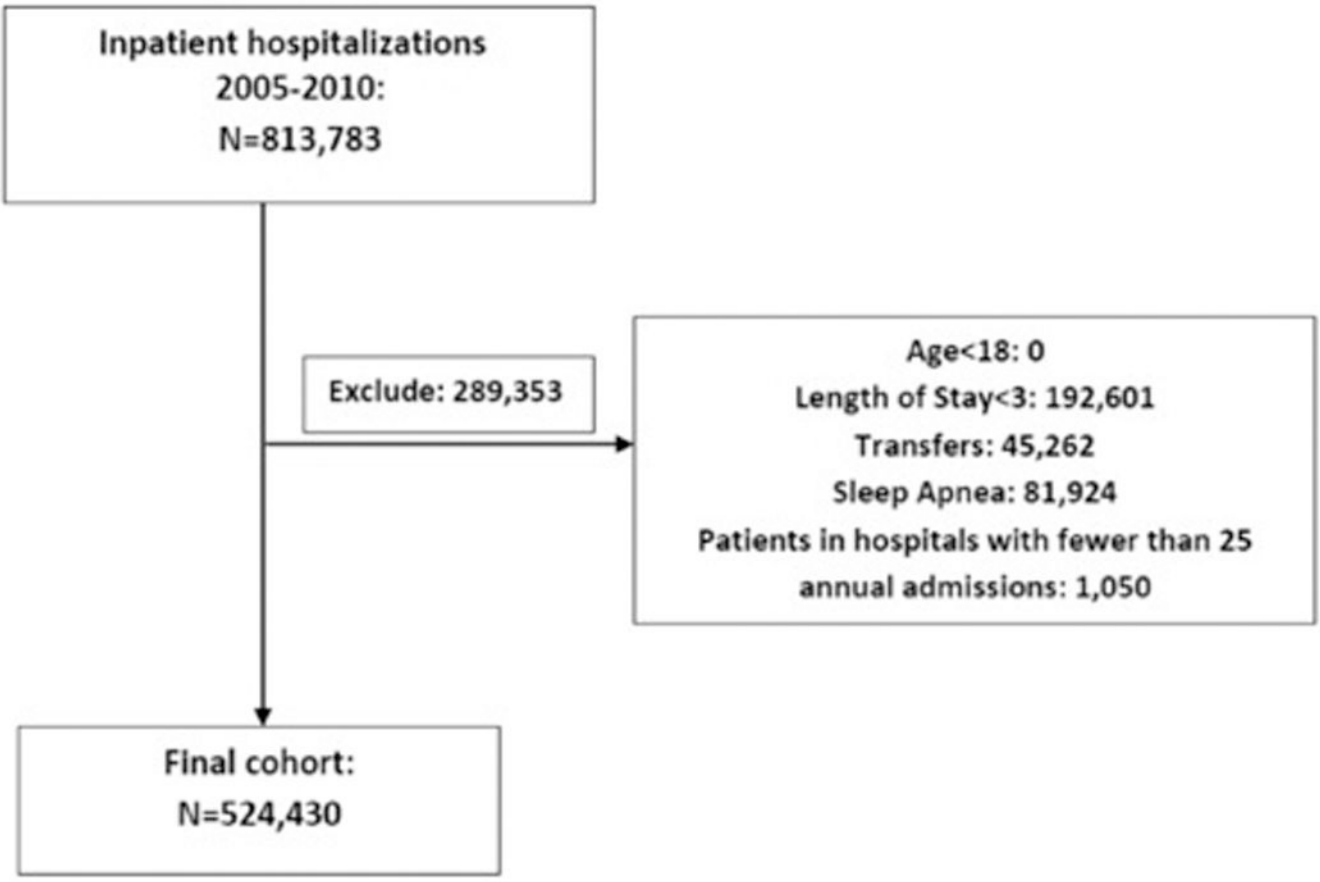

Figure 1.
Study Cohort

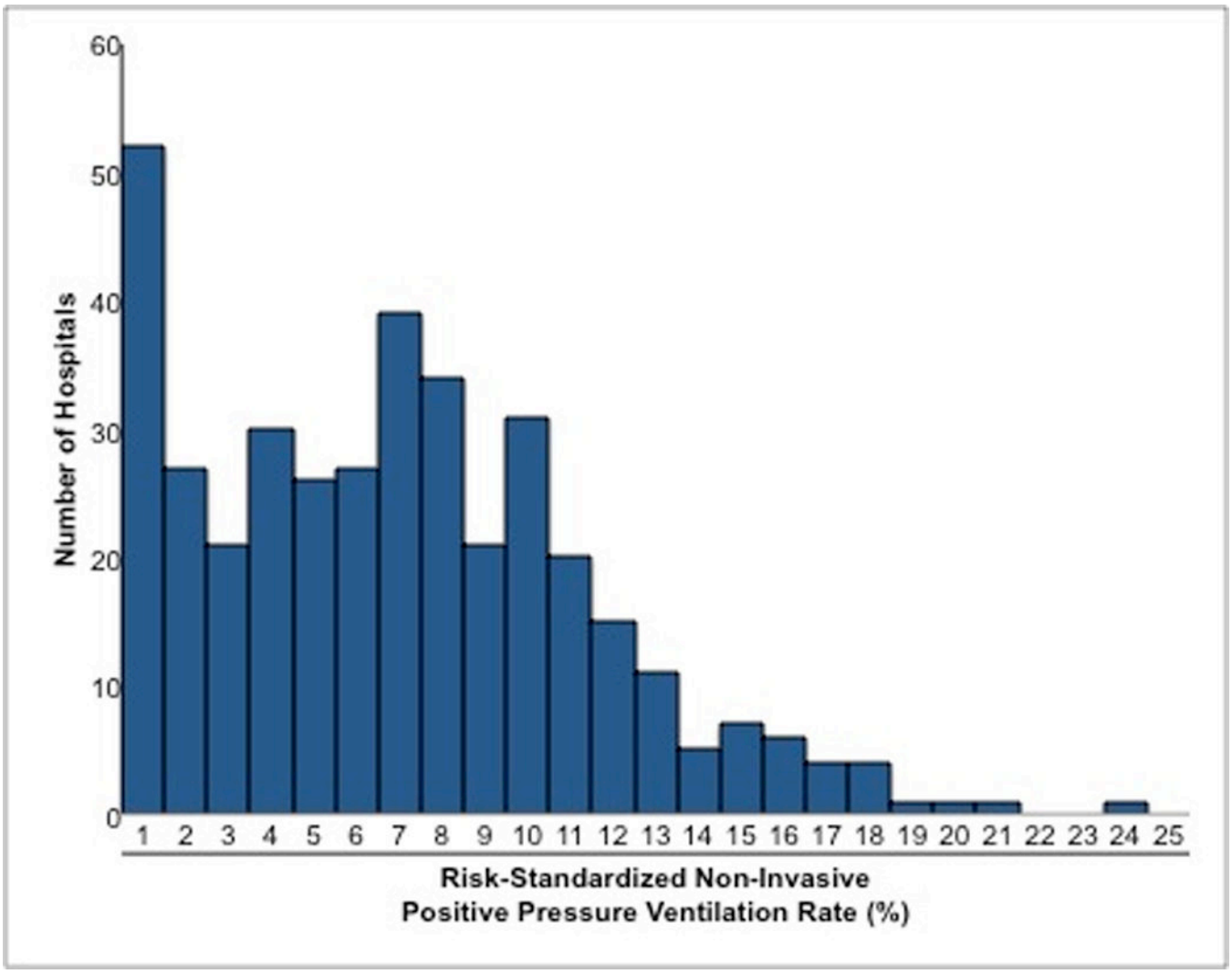

Figure 2.
Distribution of Risk-Standardized Non-Invasive Positive Pressure Ventilation Rates among Hospitals

Table 1

Patient-level Characteristics

	Overall	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Number of patients	524,430	110,000	126,285	142,888	145,257
			Percentage of Patients (%)		
Age (years)					
18–24	0.1	0.1	0.1	0.1	0.1
25–34	0.6	0.8	0.6	0.6	0.7
35–44	2.3	2.8	0.2	2.0	2.4
45–54	6.7	7.8	6.7	6.1	6.6
55–64	12.7	14.2	12.6	12.0	12.4
65–74	20.0	20.3	20.3	20.0	19.4
75+	57.5	54.1	57.5	59.2	58.4
Gender					
Male	46.0	45.9	46.3	46.0	45.8
Female	54.0	54.1	53.7	54.0	54.2
Common Comorbidities*					
Hypertension	65.9	65.6	65.3	66.9	65.6
Coronary atherosclerosis	58.2	56.9	58.9	59.2	57.4
History of VT or VF	50.1	47.6	51.5	50.0	50.8
Cardiac dysrhythmias	49.6	47.1	51.0	49.5	50.4
COPD	39.7	39.6	40.1	40.9	38.2
Renal failure	37.6	37.5	36.3	37.5	38.8
Disorders of lipid metabolism	35.6	34.2	35.7	35.7	36.6
Diabetes without chronic complications	33.3	33.3	32.4	34.2	33.1
Fluid and electrolyte disorders	32.1	31.3	31.7	31.6	33.4
Deficiency anemias	32.7	31.3	31.5	33.9	33.6
Hypothyroidism	16.4	15.6	16.5	16.7	16.6
Peripheral vascular disease	13.5	13.3	13.3	13.5	13.9
History of peripheral vascular disease	12.9	12.8	12.7	12.8	13.2
Peripheral and visceral atherosclerosis	11.4	11.3	11.1	11.3	11.8

	Overall	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Diabetes with chronic complications	10.7	10.4	10.6	10.8	10.9
Obesity	10.1	10.0	9.9	10.4	10.0
Depression	9.4	8.3	10.5	9.4	9.4
Neurological disorders	7.9	7.6	7.9	8.2	7.7
Coagulopathy	5.2	5.1	5.1	5.4	5.2

VT denotes ventricular tachycardia; VF, ventricular fibrillation; COPD, chronic obstructive pulmonary disease.

*Comorbidities present in fewer than 5% of the overall cohort are omitted from this list.

Table 2

RS-NIPPV by Hospital Characteristics

	Number of Hospitals (%)	RS-NIPPV	*P**
		Median (IQR)	
Overall	384	6.2% (2.8–9.3%)	–
Teaching Status†			
Teaching	105 (27%)	6.7% (3.1–10.6%)	0.3642
Non-Teaching	278 (73%)	6.1% (2.7–9.2%)	
Population Served†			
Urban	306 (80%)	6.4% (2.5–9.3%)	0.9963
Rural	77 (20%)	5.9% (3.4–8.3%)	
Geographic Region†			
Midwest	87 (23%)	5.6% (1.9–9.4%)	0.2696
Northeast	61 (16%)	7.0% (3.4–10.1%)	
South	162 (42%)	6.0% (2.8–8.8%)	
West	73 (19%)	6.6% (3.4–9.9%)	
Number of Beds†			
1–100	60 (16%)	4.6% (2.2–9.1%)	0.1283
101–250	113 (30%)	5.7% (2.6–8.2%)	
251–400	110 (29%)	6.9% (3.0–9.8%)	
>400	100 (26%)	6.8% (3.1–10.1%)	
Yearly Average Volume of ADHF Patients			
1–100	100 (26%)	5.6% (2.5–9.2%)	0.0945
101–250	122 (32%)	5.8% (2.6–8.9%)	
251–400	84 (22%)	6.3% (1.7–9.2%)	
>400	78 (20%)	7.0% (4.5–10.3%)	
Fraction of Patients with a Cardiologist as Attending Physician			
0–5%	152 (40%)	6.0% (3.0–9.2%)	0.6676
6–10%	58 (15%)	6.0% (2.3%–9.9%)	
11–15%	47 (12%)	7.3% (3.4%–10.0%)	
>15%	127 (33%)	6.1% (2.3%–8.7%)	
Cardiovascular Procedure Rate			
0–5%	132 (34%)	6.0% (3.1–9.1%)	0.8841
6–10%	90 (23%)	6.8% (2.3–9.6%)	
11–15%	91 (24%)	6.4% (2.3–10.0%)	
>15%	71 (18%)	6.0% (3.0–8.5%)	
ICU Admission Rate			
0–15%	69 (18%)	6.6% (2.3–8.9%)	0.9492
16–25%	182 (47%)	6.0% (3.1–9.6%)	
26–35%	74 (19%)	6.7% (3.2–9.2%)	
>35%	59 (15%)	6.1% (2.0% –8.7%)	

RS-NIPPV denotes risk-standardized non-invasive positive pressure ventilation rate; NIPPV, non-invasive positive pressure ventilation; IQR, interquartile range; ADHF, acute decompensated heart failure; ICU, intensive care unit.

*P values calculated using Kruskal-Wallis tests.

†One hospital did not have information from the American Hospital Association.

Table 3

Hospital Outcomes by Quartiles of RS-NIPPV

	Overall	Quartile 1	Quartile 2	Quartile 3	Quartile 4	*P**
			Median (IQR)			
RS-NIPPV	6.2% (2.8–9.3%)	0.9% (0.3–1.9%)	4.5% (3.6–5.6%)	7.4% (6.8–8.3%)	11.6% (10.1–14.3%)	–
RSMR	5.5% (4.7–6.4%)	5.4% (4.7–6.5%)	5.6% (4.8–6.8%)	5.6% (5.0–6.6%)	5.2% (4.4–5.9%)	0.0315
RSIR	9.8 (7.4–12.1%)	11.4% (8.1–15.4%)	9.0% (6.9–11.0%)	9.7% (7.7–11.7%)	9.1% (7.2–11.1%)	<0.0001
Median LOS	5 (5,6)	5(5,5)	5(5,6)	5(5,6)	5(5,5)	0.1095

RS-NIPPV denotes risk-standardized non-invasive positive pressure ventilation rate; IQR, interquartile range; RSMR, risk-standardized mortality rate; RSIR, risk-standardized intubation rate; LOS, length of stay.

*P values calculated using Kruskal-Wallis tests.

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Table 4

Adjusted P-Values* for Pairwise Comparisons of RSMRs and RSIRs between Quartiles of RS-NIPPV

	Quartile 1 and Quartile 2	Quartile 1 and Quartile 3	Quartile 1 and Quartile 4	Quartile 2 and Quartile 3	Quartile 2 and Quartile 4	Quartile 3 and Quartile 4
RSMR	1	1	0.939	1	0.1122	0.0438
RSIR	0.0012	0.0198	0.0006	1	1	1
Median LOS	1	1	0.7938	1	0.249	0.1932

RS-NIPPV denotes risk-standardized non-invasive positive pressure ventilation rate; RSMR, risk-standardized mortality rate; RSIR, risk-standardized intubation rate; LOS, length of stay.

* *P* values for all comparisons were calculated using Kruskal-Wallis tests and adjusted using the Bonferroni correction.