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Hospital Volume and Outcomes of Noninvasive Ventilation in Patients Hospitalized with an Acute Exacerbation of Chronic Obstructive Pulmonary Disease

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Abstract

Objective—To determine the relationship between hospital noninvasive ventilation caseload and outcomes among patients with an acute COPD exacerbation.

Design—Cross-sectional study of 13,893 patients with COPD treated with noninvasive ventilation

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Each author meets the criteria for authorship credit set forth by the International Committee of Medical Journal Editors (ICMJE), as revised in 2013. Conception and design: MS, PSP, NH, MBR; Data acquisition: PKL, PSP; Data analysis: MSS, PSP; Interpretation of data: MS, PSP, MSS, NH, MBR, KF, and PKL. All authors were involved in drafting the work, revising it critically for important intellectual content and in the final approval of the version submitted for publication

Conflict of Interest
The remaining authors have disclosed that they do not have any conflicts of interest.

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Setting—243 US hospitals participating in the Premier Inpatient Database

Patients—13,893 patients admitted between July 2009 and June 2011.

Interventions—None

Measurements and Main Results—Annual hospital volume of noninvasive ventilation was analyzed as a continuous variable, as well as after grouping it in 4 categories. The median hospital annual volume of noninvasive ventilation use was 627; and varied from 234 admissions in quartile 1 (Q1) to 1529 admissions in quartile 4 (Q4). NIV failure occurred in 15.2% and in-hospital mortality was 6.5%.

After adjusting for patient characteristics, relative to low-volume hospitals, high volume hospitals did not have lower noninvasive ventilation failure, odds ratio Q4 vs Q1: 1.05 (95% CI 0.65-1.68) or in-hospital mortality, odds ratio Q4 vs Q1: 0.88 (95% CI 0.69-1.12).

In a hierarchical multivariable analysis with adjustment for patient characteristics where volume was assessed as a continuous variable, hospital volume was not related to outcomes, including noninvasive ventilation failure (p=0.87), in-hospital mortality (p=0.88), 30-day readmission for COPD (p=0.83) or hospital length of stay (p=0.12).

Conclusions—The results of this large retrospective cohort study suggest that hospitals with higher NIV volume do not achieve better outcomes of patients with COPD exacerbation treated with NIV; even hospitals with low NIV volume are able to successfully implement this intervention.

Keywords

noninvasive ventilation; COPD; mechanical ventilation; delivery of health care; mortality; respiratory insufficiency

Introduction

Over the last two decades, numerous studies have shown a positive relationship between volume and health outcomes for a variety of surgical procedures and medical conditions.[1-3] The primary hypothesis explaining this association is that providers treating more patients acquire better skills and that hospitals with high volume develop more consistent processes of care and therefore, have better resources for taking care of patients with that condition.[1-3]

Numerous randomized controlled trials and large observational studies have shown that noninvasive ventilation (NIV) reduces the rate of endotracheal intubation and decreases mortality in patients with moderate to severe exacerbations of COPD.[4-7] However, successful implementation of NIV requires an interdisciplinary team of physicians, respiratory therapists and nurses with appropriate skills. As is the case with other complex interventions, correct selection and monitoring of patients is vital to achieving good outcomes. As providers become more experienced and comfortable using NIV, they may develop better skills in selecting patients and delivering NIV. Therefore, it is possible that, as is the case in invasive mechanical ventilation (IMV), a positive relationship between hospital volume of NIV use and patient outcomes exists.[2,8] Only one prior study, which included patients hospitalized with COPD in intensive care units (ICU) in France, addressed this topic and found that ICUs with higher case-volumes had an increased use of NIV and a trend toward lower mortality, suggesting that increasing experience favors the use of NIV and better outcomes.[9]

Using a large multihospital dataset, we examined the relationship between hospital experience of NIV use and the in-hospital outcomes of patients with an acute exacerbation of COPD (AE-COPD) treated with NIV. We hypothesized that, higher case-volume of NIV use would be associated with better patient outcomes.

Materials and Methods

Design, Setting and Patient characteristics

We conducted a cross-sectional study by analyzing data on patients hospitalized for COPD exacerbation, between July 2009 and June 2011, at 412 structurally and geographically diverse US hospitals that participate in a voluntary, fee-supported database developed to support quality improvement (Premier Healthcare Informatics, Charlotte NC). In addition to the information contained in the standard hospital discharge abstract, the database contains a date-indexed log of all items and services charged to the patient or their insurer, including medications, laboratory and radiologic tests, and therapeutic services. Data are collected electronically from participating sites, audited regularly to ensure data validity, and has been used extensively for outcomes research.[10,11]

Patients were included if they were ≥ 40 years, had a principal ICD-9 discharge diagnosis (International Classification of Disease, 9th Revision, Clinical Modification code) consistent with an exacerbation of COPD (491.21, 492.22, 491.8, 491.9, 492.8, 496) or a secondary diagnosis of COPD when accompanied by a principal diagnosis of acute respiratory failure (518.81, 518.82, 122 518.84) and were treated with systemic corticosteroids and bronchodilators. We excluded transfer patients, patients with obstructive sleep apnea, those with diagnoses of contraindications for NIV if they were present at admission. We limited the study to hospitals that participated in the database for at least one year and to obtain more stable estimates for the outcomes, we restricted the analysis to hospitals with ≥ 20 admissions of COPD treated with NIV for the period of the study.

We recorded patients' demographics, comorbidities, number of hospitalizations with COPD in the prior year, and whether NIV or IMV was used in the prior admission. Coexisting conditions were aggregated into a score, based on methods described by Gagne.[12] The comorbidity score is a single numerical score for predicting short-and long-term mortality by combining conditions in the Charlson and Elixhauser measures and providing a standardized summary of the burden of comorbidity (range: 0-24). (Supplement 1 contains additional details for the method section)

Non-invasive Ventilation Volume

Administration of NIV and IMV was identified using two approaches. First, we reviewed ICD-9 procedure codes (for NIV; 93.90 and for IMV: 96.0x, 96.70, 96.71, 96.72) and the date associated with the receipt of each procedure. Second, we used charges generated by the respiratory therapist for NIV or IMV use. We considered a patient to have received NIV or IMV during the admission if there was an ICD-9 procedure code or a charge for the procedure or service.

We chose the annual hospital volume of NIV delivered for any adult medical patient as the primary exposure variable. We used the overall hospital's experience with NIV, because the availability of the technology, staff skills, and confidence in utilizing NIV would apply to all patients with acute respiratory failure in need of mechanical ventilation.

For analysis, annual hospital NIV volume was log-transformed due to a skewed distribution. We also grouped hospitals into quartiles, on the basis of their annual hospital NIV volume based on thresholds that yielded approximately equal numbers of COPD patients treated with NIV in each volume category. In a sensitivity analysis, we used annual hospital volume of NIV delivered only to patients hospitalized with AE-COPD.

Outcomes

The primary outcome measure was NIV failure, defined as transition to IMV after an initial exposure to NIV. Length of stay, in-hospital mortality, 30-day COPD and all cause readmissions, days of NIV use and a combined NIV failure or death were examined as secondary outcomes.

Statistical analysis

Patients admitted with AE-COPD, and treated with NIV as the first or only method of ventilation were eligible for analysis. For patients with multiple eligible admissions during the study period, we selected one single observation per patient at random to avoid survival bias (as one of our outcomes was mortality). The Mantel Haenszel Chi-square test for trend across ordinal categories of hospital NIV volume was used to evaluate association of volume with patient and hospital characteristics. Hierarchical multivariable logistic regression modeling was conducted to examine the relationship between hospital NIV volume and categorical outcomes, adjusting for possible confounders (demographics, comorbidities, number of hospitalizations with COPD in the prior year, and whether NIV or IMV was used in the prior admission) and taking in account the clustering of the data at the hospital level. Linear models were used for log-transformed length of hospital stay.

We performed several sensitivity analyses. First, we restricted the cohort to patients younger than 85 years. Second, we tested for effect modification of the relationship between NIV volume and outcomes by concomitant pneumonia and by comorbidity score. Finally, we repeated our primary analyses defining the hospital volume of NIV use restricted to patients with COPD.

Statistical analyses were performed using the Statistical Analysis System (version 9.3, SAS Institute, Inc, Cary, NC). The study was approved by the Human Subjects Review Committee, of the Institutional Review Board at Baystate Medical Center.

Results

Patient and Hospital Characteristics

After applying the exclusion criteria, we identified a total of 102,942 eligible admissions with an AE-COPD, at 412hospitals. Of these, 15,474 (15.0%) received NIV as the initial ventilation strategy. After choosing one random admission per patient, and restricting to hospitals with ≥20 admissions treated with NIV, we included in the analysis a total of 13,893 patients from 243 hospitals. (Figure 1)

The median age of the patients was 69 years, 57.6% were female, 72.3% were white, and the most frequent comorbidities were hypertension, congestive heart failure, diabetes mellitus and depression. The median combined comorbidity score was 3 (IQR: 1-4), and 21.4% had a coexistent diagnosis of pneumonia at admission. Forty percent of the patients had at least one COPD admission in the year prior to the index admission, and more than one third required ventilation during a previous admission (NIV: 28.3% and IMV: 11.9%). Among all patients, in-hospital mortality was 6.5%, and the median length of hospital stay was 5 (IQR: 4-8) days. NIV failure occurred in 15.2% of the patients treated with initial NIV and hospital mortality among those with NIV failure was 18.4%. Among the 243 hospitals, the NIV use for COPD patients ranged from 3.7% to 87.4% with a median of 17.6% (IQR: 14.1%, 23.4%).

Hospital annual NIV volume, among all adult medical admissions ranged from 209 at the 10^{th} percentile hospital to 1658 at the 90^{th} percentile, with a median of 627. The median NIV volume by quartile was: 234 admissions in Q1, 489 in Q2, 757 in Q3 and 1529 in Q4. Each quartile contained at least 3,000 admissions of patients with AE-COPD treated with NIV, and the number of hospitals included was 97 in Q1, and 35 in Q4. The median annual hospital volume of AE-COPD admissions was 314 (IQR: 220-442), and the median volume of patients treated with NIV as the initial method of ventilation among patients with COPD was 73 (IQR: 51-119). The characteristics of patients and hospitals in each volume quartile category are shown in Table 1. Patients admitted to high volume hospitals were more likely to be black (Q1 6.6% to Q4 12.5%), have hypertension, diabetes and renal failure. There was a significant trend across NIV volume quartiles with greater use of NIV and IMV in a prior admission (p for trend<0.05) (for NIV: Q1 11.3% to Q4 13.3%).

The percent of patients with COPD, treated with initial NIV during hospitalization, was 14.0%, 15.6%, 17.7% and 19.0% (p<0.001) in Q1 (lowest volume) through Q4, respectively.

Compared to low NIV volume hospitals, high volume hospitals were more likely to be engaged in teaching, to be located in an urban setting and have more beds. Hospitals with high NIV volume also had a higher number of respiratory therapists, hospitalists and intensivists per hospital bed.

Association between Hospital NIV Volume and Hospital Outcomes

In unadjusted analysis, hospitals in Q1 and Q4 of NIV volume had somewhat higher NIV failure rates (16.1% in Q1 and 16.9% in Q4) compared to that of Q2 and Q3(15.3% in Q2, 12.8% in Q3, p for trends =0.74). There was no statistically significant relationship between hospital volume across quartiles of NIV use and in-hospital mortality among COPD patients treated with NIV (p = 0.17), in-hospital mortality among those with NIV failure, 30-day readmission for COPD (p = 0.36) or length of stay (p=0.09). (Table 2)

When the hospital volume was included as a continuous (log-transformed) variable in the hierarchical multivariable analysis adjusted for patient characteristics, NIV volume was not related to outcomes, including NIV failure (p=0.88), the combined outcome of NIV failure or death (p=0.98), in-hospital mortality (p=0.88), 30-day readmission for COPD (p=0.83) or hospital length of stay (p=0.12). (Table 3 and Figure 2) This non-significant relationship persisted when hospital volume of NIV was modeled categorically as quartiles. Relative to low-volume hospitals, high volume hospitals did not have lower NIV failure, odds ratio Q4 vs Q1:1.05 (95% CI: 0.65-1.68), in-hospital mortality, odds ratio Q4 vs Q1: 0.87 (95% CI 0.69-1.12), length of stay, ratio Q4 vs Q1 0.93 (95%CI 0.88-1.00), or 30-day COPD readmission, odds ratio Q4 vs Q1: 1.03 (95% CI 0.86-1.22).

Sensitivity analyses which explored the relationship between hospital NIV volume and outcomes among patients younger than 85 years of age, and analyses which computed hospital volume of NIV only among patients with COPD, yielded similar results. (See Table E1 and E2) Interaction between NIV volume and coexistence of pneumonia (p=0.84) or high comorbidity score (p=0.35) did not reach statistical significance.

Discussion

In this large retrospective study of almost 14,000 patients with COPD treated with NIV at 243 hospitals in the US, we found that patients admitted to hospitals with a higher volume of NIV use did not experience better outcomes than those treated at lower volume hospitals. The lack of relationship between NIV volume and outcomes, including NIV failure, mortality, length of stay and 30-day readmission was consistent in several sensitivity and secondary analyses, including among patients younger than 85 years of age, those with and without pneumonia, with high and low burden of comorbidity, and in an analysis that defined hospital NIV volume based on NIV experience among patients with COPD.

Over the last two decades, the relationship between volume and health outcomes has been the focus of much research. Numerous studies have found that care in institutions with higher case load is associated with better outcomes across a broad array of high-risk surgical and medical conditions.[1-3,8,9,13] A 2002 systematic review of 135 studies of 27 procedures and clinical conditions found that, in 70% of the studies included in the analysis, high volume was associated with better outcomes.[14] A strong volume-outcome relationship was also demonstrated among patients who develop acute respiratory failure requiring IMV. Two observational studies have found that nonsurgical patients ventilated with IMV who receive care at a higher volume hospital have a 5-10% lower risk of death than those being cared at a lower volume hospital.[2,8]

In this study, we hypothesized that institutions that use more NIV would be more likely to implement high-quality organizational practices and have more experienced providers with better clinical expertise for patient selection and NIV monitoring. As such, they would achieve better outcomes than institutions with lower volume and less experience. Although hospitals varied considerably in their experience with NIV, overall and among patients with COPD, we found no appreciable relationship between the hospital NIV volume and patient outcomes after adjusting for possible confounders.

There are several possible explanations for this finding. First, the use of NIV for patients with AE-COPD has increased considerably between publication of the first randomized controlled trials of NIV use in patients with AE-COPD and the timing of this study.[9,15,16] It is possible that during this time, most hospitals implemented the necessary infrastructure and processes of care for delivering NIV. Secondly, successful use of NIV among patients with AE-COPD may be related to factors such as teamwork, or hospital (or ICU) organization that may not be directly associated with NIV volume. A study of more than 70,000 patients with COPD hospitalized at 386 hospitals found that use of NIV and the outcomes associated with NIV, such as NIV failure and mortality, varied substantially across hospitals.[17] Our study shows that hospital NIV volume is not the main driving force for this variation in outcomes. Third, even hospitals in the lowest volume deciles in our study used NIV frequently for respiratory failure, with a median annual volume of 122. Thus, the volume of NIV use may have surpassed the minimum volume necessary to exceed the NIV volume-outcome inflection point. Finally, one may argue that as providers are more experienced and confident in using NIV, they employ it in patients with a higher risk of NIV failure who would have been intubated in hospitals with lower volume. In this case, the comparable NIV failure and mortality rates at lower and higher volume hospitals would be explained by the greater skill the higher volume centers applied in treating sicker patients.

Strengths and limitations

Our study has several strengths. We included a large number of patients treated with NIV, in a diverse group of US hospitals. We performed analyses using NIV volume among all patients treated at the hospital as well among patients with COPD and obtained similar results. Furthermore, our results were robust to alternative approaches for modeling volume and in several sensitivity analyses.

However, our findings should be interpreted in light of several limitations. First, as our analysis was based on administrative data, we may not have accounted effectively for all differences in patient case mix. Specifically, it is possible that high volume centers are using NIV in more marginal, difficult (i.e. sicker) patients obscuring a positive volume-outcome where one exists. Nevertheless, we controlled for several variables including prior utilization of mechanical ventilation and prior admission for COPD, and we restricted the analysis to patients treated with bronchodilators and steroids to overcome some of the limitations of using ICD-9 diagnoses for case identification. Second, we did not have information about advance directives, and in some cases, NIV could have been used for patients discharged to hospice who subsequently died outside the hospital. However, the lack of association persisted for the combined outcome of NIV failure and death, and in patients younger than 85 years of age. Third, we did not have reliable information regarding the location where NIV was delivered, a factor that may influence the risk of NIV failure. Although this issue is very important, we did not have access to detailed physiological data needed to overcome the problem of confounding by indication where sicker patients are preferentially admitted to the ICU. A recent study found that the NIV success rate was higher if NIV was delivered on the general ward than in ICU which most likely reflects the higher acuity of the ICU patients.[18] Forth, we could not distinguish if CPAP or BIPAP was used as they share the same procedure codes. Finally, because hospitals included in our study participate in a voluntary, fee-supported database used for quality improvement, it is possible that our sample is not entirely representative of other U.S. hospitals in their commitment to quality improvement. However, this is unlikely given the large sample size and hospital diversity with respect to other characteristics. Further studies should explore whether there is any volume-outcome relationship in a more broadly representative sample such as the Nationwide Inpatient Sample.

Conclusion

The results of this large retrospective cohort study suggest that hospitals with higher NIV volume do not achieve better outcomes of patients with COPD exacerbation treated with NIV; even hospitals with low NIV volume are able to successfully implement this intervention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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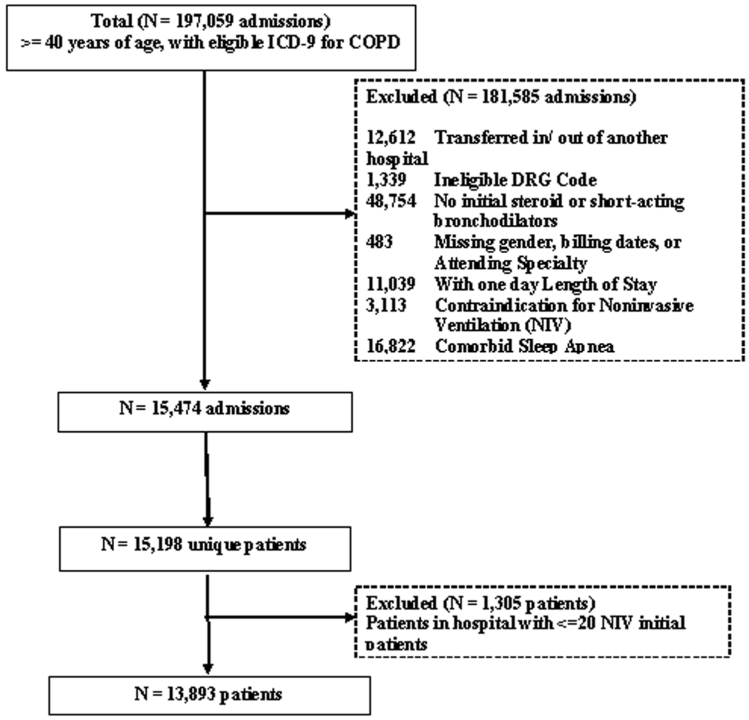

Figure 1.
Patient selection flowchart

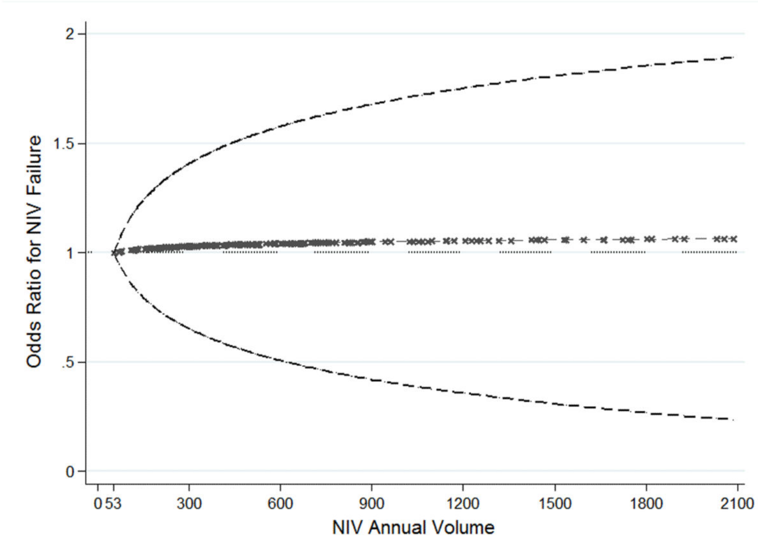

Figure 2.
Relationship between hospital volume of noninvasive ventilation volume and NIV failure. The adjusted odds of NIV failure are presented relative to the lowest annual volume (53 NIV patients per year). The markers indicate the estimated OR for the specific hospital volume for 243 hospitals. Dashed lines represent the 95 percent confidence intervals for the estimated odds ratios.

Table 1

Patient and Hospital Characteristics According to Quartiles of Hospital Noninvasive Ventilation Volume

	Q1	Q2	Q3	Q4
NIV hospital annual volume among medical patients				
Range	53-368	370-622	627-962	1022-2086
Median(IQR)	234 (187-309)	489 (450-552)	757 (675-854)	1529 (1226-1750)
NIV annual volume among patients with COPD, Median(IQR)[a]	40 (30-50)	66 (56-84)	98 (67-126)	142 (107-170)
COPD patients treated with NIV (N)	3511	3428	3532	3422
Number of hospitals	97	62	49	35
Patient Characteristics				
Age, Median(IQR)	68 (61-76)	69 (62-78)	68 (60-77)	69 (61-78)
Female (N (%))	2029 (57.8)	1980 (57.8)	2002 (56.7)	1988 (58.1)
Race [a] (N (%))				
White	2787 (79.4)	2392 (69.8)	2432 (68.9)	2431 (71.0)
Black	230 (6.6)	404 (11.8)	535 (15.1)	428 (12.5)
Hispanic	68 (1.9)	191 (5.6)	47 (1.3)	134 (3.9)
Other	426 (12.1)	441 (12.9)	518 (14.7)	429 (12.5)
Gagne Comorbidity Score, Median(IQR)[a]	3 (1-4)	3 (1-4)	3 (1-4)	3 (1-5)
Elixhauser comorbidities,	N (%)	N (%)	N (%)	N (%)
Hypertension [a]	2230 (63.5)	2249 (65.6)	2358 (66.8)	2250 (65.8)
Congestive heart failure	1222 (34.8)	1158 (33.8)	1230 (34.8)	1198 (35.0)
Diabetes [a]	1077 (30.7)	1072 (31.3)	1229 (34.8)	1105 (32.3)
Renal failure [a]	407 (11.6)	450 (13.1)	508 (14.4)	486 (14.2)
Obesity	422 (12.0)	418 (12.2)	476 (13.5)	391 (11.4)
Peripheral vascular disease [a]	275 (7.8)	310 (9.0)	352 (10)	352 (10.3)
Weight loss [a]	315 (9.0)	293 (8.5)	275 (7.8)	221 (6.5)
Pulmonary circulation disease	290 (8.3)	240 (7.0)	282 (8.0)	259 (7.6)
Neurological disorders	317 (9.0)	330 (9.6)	317 (9.0)	341 (10.0)
Depression	654 (18.6)	612 (17.9)	660 (18.7)	622 (18.2)
Pneumonia (present on admission)	786 (22.4)	755 (22.0)	671 (19.0)	764 (22.3)
IMV prior admission [a]	398 (11.3)	393 (11.5)	409 (11.6)	455 (13.3)
NIV prior admission [a]	948 (27.0)	878 (25.6)	1087 (30.8)	1024 (29.9)
Prior admission for COPD	1487 (42.4)	1339 (39.1)	1516 (42.9)	1359 (39.7)
Hospital characteristics				
Bed size [a]				
Small (<200 beds)	1896 (54.0)	259 (7.6)	180 (5.1)	0 (0.0)

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	Q1	Q2	Q3	Q4
Medium (200-399)	1332 (37.9)	2361 (68.9)	1601 (45.3)	784 (22.9)
Large (400+)	283 (8.1)	808 (23.6)	1751 (49.6)	2638 (77.1)
Region [a]				
Midwest	468 (13.3)	498 (14.5)	509 (14.4)	508 (14.8)
Northeast	726 (20.7)	671 (19.6)	583 (16.5)	633 (18.5)
South	1599 (45.5)	1570 (45.8)	1962 (55.5)	1682 (49.2)
West	718 (20.5)	689 (20.1)	478 (13.5)	599 (17.5)
Teaching [a]	421 (12.0)	1060 (30.9)	1382 (39.1)	1897 (55.4)
Urban [a]	2663 (75.8)	3013 (87.9)	2722 (77.1)	3270 (95.6)
Respiratory therapist/ Bed ratio [ab]				
Missing	802 (22.8)	769 (22.4)	723 (20.5)	662 (17.5)
< 5.36	1112 (31.7)	651 (19.0)	644 (18.2)	280 (14.8)
5.36 – 8.45	776 (22.1)	1376 (40.1)	1035 (29.3)	700 (18.5)
> 8.461	821 (23.4)	632 (18.4)	1130 (32.0)	1780 (49.2)
NIV initial use among COPD patients [a]	14.0%	15.6%	17.7%	19.0%
IMV initial use among COPD patients	4.9%	6.4%	5.1%	5.6%

[a] p-value < .05, test for trend across quartiles of volume

[b] Each staff member is Full Time Equivalent (FTE) to 100 beds

Table 2

Outcomes and their Association with Quartiles of Hospital Noninvasive Ventilation Volume

	Q1	Q2	Q3	Q4	p-value [a]
NIV Volume (range of pts/yr)	**53-368**	**370-622**	**627-962**	**1022-2086**	
NIV failure					
Observed Rate, n(%)	564 (16.1)	524 (15.3)	451 (12.8)	577 (16.9)	0.75
Adjusted odds ratio (95% CI)	Ref	1.08 (0.72-1.60)	0.94 (0.61-1.44)	1.05 (0.65-1.68)	-
In-hospital mortality					
Observed Rate, n(%)	235 (6.7)	232 (6.8)	226 (6.4)	204 (6.0)	0.17
Adjusted odds ratio (95% CI)	Ref	1.01 (0.81-1.26)	1.01 (0.80-1.27)	0.87 (0.69-1.12)	-
In-hospital mortality among NIV failure					
Observed Rate, n(%)	96 (17.0)	112 (21.4)	95 (21.1)	87 (15.1)	0.28
Adjusted odds ratio (95% CI)	Ref	1.38 (0.92-2.08)	1.40 (0.91-2.15)	1.04 (0.66-1.64)	
Any readmission					
Observed Rate, n(%)	612 (18.7)	544 (17.0)	598 (18.1)	609 (18.9)	0.20
Adjusted odds ratio (95% CI)	Ref	0.91 (0.79-1.05)	0.92 (0.79-1.06)	1.01 (0.87-1.17)	-
COPD readmission					
Observed Rate, n(%)	385 (11.8)	338 (10.6)	383 (11.6)	392 (12.2)	0.36
Adjusted odds ratio (95% CI)	Ref	0.93 (0.78-1.11)	0.91 (0.77-1.09)	1.03 (0.86-1.22)	-
Length of Stay					
Observed Rate, n(%)	5 (4-8)	6 (4-9)	5 (4-8)	5 (3-8)	0.09
Adjusted ratio (95% CI)	Ref	1.03 (0.98-1.09)	1.00 (0.94-1.06)	0.93 (0.88-1.00)	-
NIV days					
Observed Rate, n(%)	2 (1-4)	2 (1-4)	2 (1-4)	2 (1-4)	0.31
Adjusted ratio (95% CI)	Ref	1.06 (0.95-1.18)	1.09 (0.97-1.22)	1.02 (0.90-1.16)	-

[a] p-values from test for trend across quartiles

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Table 3

Adjusted patient outcomes using NIV volume as continuous variable (log transformed)

	OR (95% CI)	p-value
Mortality	0.99 (0.88 - 1.11)	0.88
NIV failure	1.02 (0.82 - 1.26)	0.88
Any readmission	1.00 (0.93 - 1.07)	0.93
COPD Readmission	1.01 (0.93 - 1.10)	0.83
NIV day	1.03 (0.97 - 1.09)	0.30
Length of Stay	0.98 (0.95 - 1.01)	0.12
NIV failure or mortality	1.00 (0.84 - 1.19)	0.98