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# High Resource Utilization Does Not Affect Mortality in Acute Respiratory Failure Patients Managed with Tracheostomy

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Running Title: Tracheostomy Practice Variation and Outcome.

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Conflict of Interest Statement: As noted, two authors (SM, SFM) are employed by University Healthsystems Consortium, Oakbrook, IL. There are no additional potential conflicts of interest to disclose.

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**ABSTRACT**

Background: Tracheostomy practice in patients with acute respiratory failure (ARF) varies greatly amongst institutions. This variability has the potential to be reflected in the resources expended providing care. In various healthcare environments, increased resource expenditure has been associated with a favorable effect on outcome. We undertook the current investigation to examine the association between institutional resource expenditure and mortality in ARF patients managed with tracheostomy.

Methods: We developed analytic models employing the University Healthsystems Consortium (Oakbrook, IL) database. Administrative coding data were used to identify patients with the principal diagnosis of ARF, procedures, complications, post-discharge destination and survival. Mean resource-intensity (RI) of participating academic medical centers (AMCs) was determined using risk-adjusted estimates of costs. Mortality risk was determined using a multivariable approach which incorporated patient-level demographic and clinical variables and institution-level RI (SAS 9.2, SAS Institute, Cary NC).

Results: We analyzed data from 44,124 ARF patients; 4,776 (10.8%) of whom underwent tracheostomy. Compared to low RI settings, treatment in high RI AMCs was associated with increased risk of mortality (OR (95% CI) 1.114 ((1.049- 1.763)) including those managed with tracheostomy (high RI AMC*tracheostomy: 1.104 (1.040-1.168)). We examined the relationship between complication development and outcome. While neither the profile nor number of complications accumulated differed comparing treatment environments ($p>0.05$ for both), mortality for tracheostomy patients experiencing complications was greater in high (95/313 (30.3%)) vs. low RI (552/2587 (21.3%)) AMCs ($p<0.001$).

Conclusions: We were unable to demonstrate a positive relationship between resource expenditure and outcome in ARF patients managed with tracheostomy. Future investigations in this area should focus on identifying clinically beneficial strategies, and assessing the cost-effectiveness of these strategies when applied in diverse clinical environments.

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**KEY WORDS**

Tracheostomy, acute respiratory failure, mechanical ventilation, critical illness, practice variation, quality assurance.

**ABREVIATIONS**

AHRQ – Agency for Healthcare Research and Quality; ARF – Acute Respiratory Failure; LOS – length of stay; RI-resource intensity; RCC – ratio of cost to charges; ROM – risk of mortality; SOI – severity of illness; UHC – University Healthsystems Consortium.

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**INTRODUCTION**

Tracheostomy is one of the most commonly performed surgical procedures among patients with acute respiratory failure (ARF)(1-4). Though a minority of all individuals requiring ventilatory support, tracheostomy patients place significant demands on ventilator, intensive care unit (ICU), hospital and post-hospital discharge resources(5-7). Financial expenditures to support the care of tracheostomy patients are among the highest of any diagnostic or procedural group(8). Efforts to refine tracheostomy practice have the potential to affect both the quality of care provided this segment of the critically ill population, as well as the resources expended delivering this care(9-11).

Despite decades of experience, the potential advantages of tracheostomy, relative to prolonged translaryngeal intubation, remain poorly defined, as do the risks associated with this procedure(2;9). Timing of tracheostomy has been particularly debated. Rodriguez *et al* reported that tracheostomy performed within the first week of ICU admission following major trauma was associated with significantly shorter duration of mechanical ventilation and ICU length of stay (LOS) compared with tracheostomy performed later in the course of respiratory failure(12). Other investigators have confirmed(13;14) and contradicted(15-17) the putative benefits of early tracheostomy. Three recently completed randomized controlled trials suggest that timing of tracheostomy does not affect incidence of infectious complications, duration of mechanical ventilation, or ICU or hospital length of stay(18-20). Currently, there are no well established standards to guide patient selection or other aspects of this procedure. Absent such standards, tracheostomy appears to be used in, at worst, an arbitrary and, at best, a variable fashion(5;21;22).

As is the case with critical care practice in general, variation in management of tracheostomy patients has the potential to be reflected in variability in the resources utilized in providing care(23). In some healthcare settings, increased resource

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expenditure appears associated with favorable effects on outcome(24-27). We undertook the current investigation to examine the hypothesis that increased resource expenditure associated with the management of tracheostomy patients – controlling for potentially confounding variables - is associated with a beneficial effect on mortality.

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## METHODS

### Description of data resource and identification of patients

This study is based on analysis of the University Healthsystems Consortium (UHC, Oakbrook, IL) data resource (https://www.uhc.edu/). UHC is a network of university-based tertiary care institutions and affiliated hospitals representing 90% of the nation's non-profit academic medical centers (AMCs). UHC has developed a highly detailed administrative database which enables comparative analysis in clinical, operational, financial, and patient safety domains among participants.

Adult patients (≥18 years of age) with the principal diagnosis of ARF (ICD-9 diagnosis code 518.81) and requiring mechanical ventilation were identified through use of ICD-9 procedure codes for ventilator support of any duration (*96.70* – Continuous invasive mechanical ventilation of unspecified duration, *96.71* - Continuous invasive mechanical ventilation for less than 96 consecutive hours, *96.72* - Continuous invasive mechanical ventilation for 96 consecutive hours or more, *96.7* – Other continuous invasive mechanical ventilation). Patients undergoing tracheostomy were identified in a similar fashion (*31.1* – temporary tracheostomy).

### Risk adjustment

The approach to risk adjustment used in this study has been previously described(28-30). Briefly, two independent models (hospital cost and probability of inpatient mortality) were constructed for each Diagnosis Related Group (DRG) or Base MS-DRG. Each model incorporated an APR-DRG severity of illness (SOI) or risk of mortality (ROM) category (SOI and ROM each are assigned a score on a 4-point scale of '1' – 'minor' to '4' – 'extreme'), as well as 29 specific comorbidities identified by the Agency for Healthcare Research and Quality (AHRQ) as influencing the outcome of interest(31). For model development, data were partitioned into derivation and validation data sets and assessed using standard diagnostics (*c*-index, Hosmer-Lemeshow test, and R-square). In the event that it was not possible to develop a stable model by this approach, each case in the DRG or Base MS-DRG was assigned the

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average observed value stratified first by SOI or ROM and then by transfer status within each SOI or ROM level. Cost of patient care was assessed using ratio of cost to charges (RCC) methodology. Detailed charges were collected at the revenue code level and were mapped into departments and cost centers, consistent with Centers for Medicare & Medicaid Services descriptions. CMS cost reports were used to obtain service line costs and charges which were used to calculate an RCC for each service. In addition, an RCC for each cost center within the hospital as well as a global RCC for the hospital was generated. These RCC's were used to estimate percentiles for refining or trimming the data to eliminate outliers. Estimated service center costs were derived from multiplying charges by the RCC. Total costs were computed by summing individual cost center estimates. A predicted value of cost and probability of mortality were assigned to each patient record in the data set.

**Identification of complications**

UHC has developed and validated methodology to identify 25 specific complications based on diagnosis and procedural codes: postoperative stroke, aspiration pneumonia, postoperative pulmonary compromise, postoperative gastrointestinal hemorrhage or ulceration, postoperative urinary tract complication, cellulitis or decubitis ulcer, septicemia, postoperative/intra-operative shock due to anesthesia, reopening of surgical site, mechanical complication due to device or implant, miscellaneous complications, shock or respiratory arrest, central or peripheral nervous system complication, postoperative acute myocardial infarction, postoperative myocardial abnormality (excluding myocardial infarction), postoperative infections excluding pneumonia or wounds, procedure related perforations or lacerations, postoperative coma or stupor, postoperative pneumonia, postoperative physiologic or metabolic derangements, complications related to anesthetic or CNS agents, venous thrombosis/pulmonary embolism, wound infection, post-procedure hemorrhage or hematoma, and other complications of procedures (https://www.uhc.edu/).

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**Approach to analysis**

We evaluated the relationship between inpatient mortality, presence of tracheostomy, and resource-intensity (RI) using multivariable logistic regression. RI was operationalized for all ARF patients in a given facility, not for the individual patient. We took this approach because we have previously documented significant inter-institutional differences in tracheostomy practice (in terms of proportion of patients undergoing this procedure as well as timing) and felt that institution-level RI would reflect this variation(5). Average RI was estimated for each facility by dividing total costs associated with providing care by expected cost as predicted by the UHC algorithm. We hypothesized that increased RI would result in a beneficial effect on survival and took two approaches to incorporating RI into our analytic model. In the first approach, RI was modeled as a dichotomous variable such that a facility that consumed ≥25% of predicted resources (i.e., a proportional expense ratio (PER) $\geq$ 1.25) was considered 'high' RI, while a facility providing care associated with a PER ratio < 1.25 was considered 'low' RI. Institutional PER was stable over the years included in this study, accordingly we pooled data over this time period for analysis (**Online supplement 1**). Stratifying the institutions into 'high' and 'low' RI categories has the potential to introduce bias. To compensate for this potential bias, and to more generally examine the relationship between resource expenditure and outcome, we also modeled RI as a continuous variable. Univariate analyses were conducted using logistic regression to identify variables that potentially confound the relationship between mortality and resource use. In building our multivariable model, we controlled for the possibility that the relationship between mortality and tracheostomy might vary by level of RI by including these 2 variables as an interaction term. All analyses were conducted using SAS 9.2 (SAS Institute, Cary NC). For ease of presentation, findings presented in the 'Results' section represent the dichotomous model; the online supplement presents the findings of RI modeled as a continuous variable.

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**Human Subjects Protection**

The data used in this analysis represented a limited data set (i.e., contained no direct patient identifiers) that was originally collected for non-research purposes. As such, this study was classified as 'exempt' by the Washington University School of Medicine Human Research Protection Office (i.e., did not involve human subjects) (HRPO 10-1190).

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## RESULTS

### Characteristics of Academic Medical Centers (AMC's), patients and tracheostomy practice

We analyzed data from 44,124 patients with the principal diagnosis of ARF cared for in 102 AMC's (mean (±SD) 575 (±218.1) licensed beds, 432.5 (±258.5) patients contributed per center) over a 7-year period (2002-2008). Overall, 4,776 of these individuals (10.8%) underwent tracheostomy (rate per center (±SD) 10.8 (±3.0) %). Tracheostomy and non-tracheostomy patients differed significantly with respect to several baseline variables (age, ethnicity, admission status, comorbidity, and payer source). (**Table 1**) Further, tracheostomy patients had higher rates of morbidity but lower rates of mortality than non-tracheostomy patients. Finally, relative to non-tracheostomy patients, patients with tracheostomy were more resource-intensive to manage as evidenced by longer ICU and hospital LOS, higher total hospital costs, and greater likelihood of being discharged to an inpatient facility (long term care facility, skilled nursing facility, rehabilitation facility). (**Table 2**)

### Differences in tracheostomy patient outcomes analyzed by resource intensity (RI) of the care environment

One hundred and two university-affiliated AMC's were included in this analysis. Twelve AMCs were designated as high RI (i.e., proportional expense ratio ≥1.25 and corresponding to 4,435 patients, 369.5 (±200.6) patients per center) and 90 as low RI (i.e., proportional expense ratio <1.25 and corresponding to 39,689 patients, 441.0 (±265.6) patients per center). High and low RI institutions were similar with respect to number of licensed beds (603.6 (±273.7) vs. 571.5 (±213.8), p=0.637) and number of annual discharges for patients with ARF (370 (±200) vs. 441 (±265), p=0.439). Rates of tracheostomy did not differ comparing these 2 environments (510/4,435 (11.5%) in high RI institutions vs. 4,246/39,689 (10.7%) in low RI institutions, respectively, *p=0.133*). (**Table 3**)

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Variables found to be associated with mortality in univariate analysis were age, gender, probability of inpatient mortality, ICU LOS, non-ICU length of stay, race, admission status (emergent vs. non-emergent), payer source, presence of complications, and comorbidities present on admission (**Table 4**). In our multivariable analysis, we found that being cared for in a high RI environment was associated with increased risk of mortality (OR=1.114, 95% CI: 1.049 - 1.763) while use of tracheostomy had no mortality effect (OR=0.991, 95% CI: 0.919 - 1.063). However, the interaction term in our multivariable model demonstrated that tracheostomy patients managed in high RI settings were at increased risk of death (OR=1.104, 95% CI: 1.040 -1.168) (**Table 5**). Results were comparable whether RI was modeled as a dichotomous or continuous variable (**Online Supplement 2**).

We explored possible reasons that might underlie our finding of an unfavorable relationship between RI and outcome for tracheostomy patients. To examine whether this relationship might be the result of early discharge of patients at high risk of mortality from low RI settings, we analyzed post-hospital discharge destination. We found that there was a non-statistically significant trend towards high RI settings being more likely to transfer patients to other inpatient institutions following discharge (consisting of skilled nursing facilities (115/406 (28.5%)), Intermediate care facilities (156/406 (38.5%)), rehabilitation centers (72/406 (17.7%)), general hospitals (36/406 (8.9%)) and other environments (26/406 (6.4%)), with low RI settings being more likely to discharge patients to home (**Table 6**). We considered whether the increased risk of mortality we observed may be related to an increased number or type of complications in high RI settings. However, we found that the average number (1.54 (±0.65)/patient low RI vs. 1.60 (±0.22)/patient high RI, *p=0.130*), incidence (mean 0.0362 (±0.0653) complications/patient/day low RI vs. 0.0337 (±0.0723) complications/patient/day high RI, *p=0.114*) and profile (p=ns for all) of complications were similar comparing these 2 settings. Finally, we examined the relationship between complications and mortality. We found that mortality for tracheostomy patients experiencing complications was

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greater in high compared with low RI environments (95/313 (30.3%) vs. 552/2587 (21.3%), respectively, *p <0.001*). In contrast, mortality for tracheostomy patients not experiencing complications was similar comparing these settings (41/197 (20.8%) vs. 297/1679 (17.7%) respectively, *p=0.327*).

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**DISCUSSION**

The relationship between resource expenditure and outcome in health care settings is variable(23-27). Stukel *et al* found that higher levels of expenditure were associated with decreases in 30-day mortality, 1-year mortality, and major cardiac events among patients presenting to acute care hospitals with a variety of diagnoses(24;25). In contrast, Garland *et al* reported that variation in discretionary resource use among individual medical intensivists did not translate into differences in in-hospital mortality or length of stay(23). Given the variability in tracheostomy utilization and the resource consumption associated with providing care to patients undergoing this procedure, we examined the effects of resource expenditure in this setting. Consistent with the findings of prior studies, the resource expenditure associated with providing care to this patient population was significant, with total aggregate costs exceeding $1.6 billion(1;3;4). Though representing only 10% of our sample, tracheostomy patients accounted for 28.4% of these costs (collectively, $463 million). We limited our analysis to those patients with the principal diagnosis of ARF, assuming that indication for tracheostomy would be more consistent across institutions than if all individuals, irrespective of principal diagnosis were included. Nonetheless, individuals in this study were complex, possessed significant co-morbid illness, and experienced a death rate exceeding 25%. Patients undergoing tracheostomy experienced lower rates of mortality compared with non-tracheostomy patients. Whether this resulted from practitioners targeting this intervention to individuals most likely to survive the acute episode of illness, or whether patients undergoing tracheostomy survived until transfer to a non-acute hospital setting and then succumbed cannot be discerned from this analysis. Further, patients managed with tracheostomy experienced comparatively higher complication rates, longer ICU and hospital lengths of stay, and accumulated greater global costs, relative to their non-tracheostomy counterparts. We based institutional RI on risk-adjusted estimates of costs associated with providing care. In contrast both to prior studies and our stated hypothesis, we found an inverse relationship between resource expenditure and outcome(23-27). Specifically, compared with low RI settings, patients managed in high RI institutions experienced greater in-hospital mortality with

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the presence of tracheostomy being associated with as great as an additional 17% increased likelihood of death. Thus, not only did institutions appear to differ with respect to the costs associated with providing care, the additional resources expended in high RI settings did not appear to positively affect outcome.

We took two complementary approaches to performing our analysis, one in which institutions were stratified into high- and low-RI categories, and the second in which RI was modeled as a continuous variable. The intent of this latter approach was to compensate for any bias that discrete modeling of this variable might introduce (i.e., arbitrary assignment of high- and low- designation). Both methodologies produced comparable findings. We explored potential reasons that might underlie our observed relationship between RI and mortality. We reasoned that low RI environments may appear to have more favorable outcomes for tracheostomy patients because of more timely transfer to other inpatient settings (such as skilled nursing or long term weaning facilities). Deaths occurring in such settings would not be captured as inpatient mortality. However, not only were low and high RI environments similar with respect to post-hospital discharge destinations, there was a trend for low RI environments to more commonly discharge patients to home. We similarly reasoned that higher rates of complications may underlie the greater resource expenditure and higher mortality in high RI environments. Again, we found that low and high RI environments were similar with respect to the incidence and total number of complications patients experienced. However, mortality for tracheostomy patients who had experienced complications was greater in high RI than low RI environments, suggesting a limited ability to rescue patients following the development of complications. Potentially, these findings result from important differences in the patient populations comparing low- and high-RI settings which were not adequately adjusted for in our analysis. Thus, high-RI institutions may have managed patients of greater acuity, explaining more common discharge to inpatient settings and higher mortality following the occurrence of complications. Accordingly, one must be circumspect in these interpretations.

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Recent studies examining tracheostomy implementation have focused on specific outcomes such as duration of mechanical ventilation, ICU LOS, and sedative use(18-20). One interpretation of the current analysis is that it is difficult to disaggregate use of tracheostomy from other facets of care. ICUs which apply differing approaches to ventilator weaning, sedation, venous thromboembolism prophylaxis, and other interventions may likewise differ significantly in the manner in which they apply tracheostomy use(32-34). Further, care of the patient post-tracheostomy (approaches to phonation, nutrition, re-conditioning, and decannulation) might likewise differ among institutions and influence outcome(9). Our dataset does not provide us with information as to the manner with which care was provided, limiting our ability to identify factors and behaviors underlying the outcomes observed. Further, we lack knowledge of factors that might prompt decision for tracheostomy (e.g., repetitive extubation failure, lack of progress on sequential weaning trial attempts, etc.). An appreciable proportion of the patients described in this study reported Medicare or Medicaid as a payer source; reimbursement considerations and similar non-clinical factors may have influenced the decision for tracheostomy in some contexts. Determining these factors (through site visits, inventory of practices, etc.) and translating approaches effective at well-performing institutions to those that perform suboptimally would be one approach to enhancing patient safety and quality.

Our investigation has several additional limitations. UHC is a network of AMCs which may be self-selecting in terms of commitments to quality assurance initiatives and other attributes. The severity of illness and complexity of patients cared for in these institutions may differ substantially from other settings (particularly non-academic institutions), limiting the ability to generalize these findings. In addition, this analysis is based on administrative coding data. These codes are designed to enable billing and are not necessarily a direct reflection of medical care received. Inaccuracy is potentially introduced through code attribution by non-clinical

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personnel. These shortcomings are partly offset by the fact that such codes are standardized, appropriately updated, and reasonably specific. Their availability in large numbers has the potential to 'drown out' statistical noise and error. Further, our analysis might be confounded by the possibility that patient complexity is directly related to both resource intensity and likelihood of poor outcome. We structured our multivariable model so as to control for this possibility, stratifying hospitals based on previously validated risk-adjusted estimates of costs associated with providing care(28-30). Though this method was uniformly applied to all institutions in our sample, it might not adequately account for all factors critical to outcome. For instance, geography and setting (i.e., urban, suburban) may be an influential demographic factor that we did not capture. These and other types of limitations might be further magnified by the lack of inclusion of physiologic data (e.g., APACHE score) which might have allowed us to further refine our estimates of illness acuity. Similarly, while we identified a large number of complications, many were defined in the context of the postoperative state. Thus, some important adverse events might go undetected. Finally, we undertook an institution-wide assessment of tracheostomy practice focusing on patients with ARF. This approach ignores the very real differences in tracheostomy utilization and critical care practice that might exist within specific hospital domains (e.g., comparing surgical and medical ICUs), and our findings might not be reflective of other disease processes (e.g., acute neurological insult or polytrauma).

**CONCLUSION**

We were unable to demonstrate a positive relationship between resource expenditure and outcome in ARF patients managed with tracheostomy. Given the exploratory nature of this study, one must be circumspect at any conclusions drawn. Our analysis does suggest several potential avenues of further inquiry. Among these are investigations that focus on identifying clinically beneficial strategies related to tracheostomy patient selection, timing, technique, and post-procedure management, and assessing the cost-effectiveness of these strategies when applied across diverse clinical environments.

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**Table 1**: Baseline Characteristics of Adult Patients with Acute Respiratory Failure cared for in Academic Medical Centers (AMCs)[1]

| | All patients (n=44,124) | Non-tracheostomy (n=39,348) | Tracheostomy (n=4,776) | *p-value*[2] |
|---|---|---|---|---|
| Age (mean (±SD) years) | 61.3 (±21.0) | 61.4 (±19.8) | 60.4 (±13.8) | *<0.001* |
| Male Gender | 22,635 (51.3) | 20,146 (51.2) | 2,478 (51.9) | *0.42* |
| Race | | | | *0.005* |
| *Caucasian* | 25,680 (58.2) | 22,782 (57.9) | 2,870 (60.1) | |
| *African American* | 13,237 (30.0) | 11,096 (28.2) | 1,232 (25.8) | |
| *Hispanic* | 1,941 (4.4) | 1,770 (4.5) | 205 (4.3) | |
| *Other* | 4,147 (9.4) | 3,699 (9.4) | 468 (9.8) | |
| Admission status | | | | *<0.001* |
| *Emergency* | 31,857 (72.2) | 28,763 (73.1) | 3,109 (65.1) | |
| *Urgent* | 10,060 (22.8) | 8,735 (22.2) | 1,337 (28.0) | |
| *Elective* | 1,676 (3.8) | 1,416 (3.6) | 243 (5.1) | |
| *Other (NA)* | 485 (1.1) | 393 (1.0) | 86 (1.8) | |
| Comorbid conditions | | | | |
| *Hypertension* | 23,165 (52.5) | 20,893 (53.1) | 2,306 (48.3) | *<0.001* |
| *Fluid and electrolyte disorders* | 21,753 (49.3) | 18,926 (48.1) | 2,808 (58.8) | *<0.001* |
| *Chronic pulmonary disease* | 21,488 (48.7) | 19,280 (49.0) | 2,173 (45.5) | *<0.001* |
| *Congestive Heart Failure* | 15,972 (36.2) | 14,283 (36.3) | 1,685 (35.3) | *0.192* |
| *Diabetes* | 13,104 (29.7) | 11,725 (29.8) | 1,399 (29.3) | *0.51* |
| *Anemia* | 11,560 (26.2) | 10,033 (25.5) | 1,542 (32.3) | *<0.001* |
| *Neurological disorder* | 9,177 (20.8) | 7,987 (20.3) | 1,217 (25.5) | *<0.001* |
| *Renal failure* | 7,809 (17.7) | 7,043 (17.9) | 773 (16.2) | *0.005* |
| *Psychiatric disorder (depression, psychoses)* | 7,015 (15.9) | 6,295 (16.0) | 716 (15.0) | *0.073* |
| *Malignancy* | 4,324 (9.8) | 3,895 (9.9) | 454 (9.5) | *0.477* |
| *Weight loss* | 1,720 (3.9) | 983 (2.5) | 750 (15.7) | *<0.001* |
| *Valvular heart disease* | 794 (1.8) | 629 (1.6) | 1,141 (23.9) | *<0.001* |
| *Peripheral vascular disease* | 485 (1.1) | 189 (0.5) | 314 (6.6) | *<0.001* |
| *Hypothyroidism* | 441 (1.0) | 138 (0.5) | 286 (6.0) | *<0.001* |
| *Peptic ulcer disease* | 383 (0.9) | 338 (0.9) | 45 (0.9) | *0.628* |
| *Collagen vascular disease* | 105 (0.2) | 106 (0.3) | 1 (0.1) | *0.001* |
| *AIDS* | 83 (0.2) | 43 (0.1) | 40 (0.8) | *<0.001* |
| *Pulmonary vascular disease* | 70.5 (0.1) | 70 (0.2) | 2 (0.1) | *0.044* |
| *Coagulopathy* | 61.7 (0.1) | 51 (0.1) | 13 (0.3) | *0.021* |
| *Liver disease* | 52 (0.2) | 11 (0.0) | 40 (0.8) | *<0.001* |
| Payer source | | | | *<0.001* |
| *Commercial insurance* | 7,898 (17.9) | 6,964 (17.7) | 916 (19.2) | |
| *Medicare* | 23,782 (53.9) | 21,147 (54.0) | 2,536 (53.1) | |
| *Medicaid* | 7,324 (16.6) | 6,374 (16.2) | 917 (19.2) | |
| *Self pay* | 1,985 (4.5) | 1,888 (4.8) | 119 (2.5) | |
| *Other* | 2,912 (6.6) | 2,675 (6.8) | 258 (5.4) | |
| *NA* | 176 (0.4) | 157 (0.4) | 24 (0.5) | |

[1]Numbers in parentheses represent percentage (%) except where noted.

[2]Comparison is for tracheostomy and non-tracheostomy patients.

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**Table 2**: Outcomes of Adult Patients with Acute Respiratory Failure cared for in Academic Medical Centers[1]

| | All patients (n=44,124) | Non-tracheostomy (n=39,348) | Tracheostomy (n=4,776) | *p-value* |
|---|---|---|---|---|
| Complications | 5,780 (13.1) | 2,872 (7.3) | 2,899 (60.7) | *<0.001* |
| Mortality | 11,781 (26.7) | 10,781 (27.4) | 984 (20.6) | *<0.001* |
| ICU LOS (mean (±SD) days) | 8.5 (±10.5) | 6.6 (±7.9) | 24.3 (±20.7) | *<0.001* |
| Hospital LOS (mean (±SD) days) | 14.1 (±21.0) | 11.3 (±19.8) | 36.6 (±27.6) | *<0.001* |
| Total Hospital Costs (mean (±SD) $) | 107,705 (±151,131) | 86,118 (±107,771) | 285,509 (±292,813) | *<0.001* |
| Discharge destination (survivors) | | | | *<0.001* |
| *Home (outpatient care)* | 18,929 (42.9) | 18,493 (47.0) | 602 (12.6) | |
| *Hospice* | 1,014 (2.3) | 944 (2.4) | 72 (1.5) | |
| *Inpatient setting (acute care hospital, rehab, SNF, etc.)* | 23,959 (54.3) | 19,753 (50.2) | 4,069 (85.2) | |
| *NA* | 221 (0.5) | 157 (0.4) | 33 (0.7) | |

[1]Numbers in parentheses represent percentage (%) except where noted.

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**Table 3**: Outcomes of Adult Patients with Acute Respiratory Failure comparing High and Low resource intensity institutions[1]

| | All patients (n=44,124) | High RI (n=4,435) | Low RI (n=39,689) | *p-value* |
|---|---|---|---|---|
| Complications (%) | 5,780 (13.1) | 638 (14.4) | 5,159 (13.0) | *0.007* |
| Mortality (%) | 11,781 (26.7) | 1,357 (30.6) | 10,438 (26.3) | *<0.001* |
| Tracheostomy (%) | 4,765 (10.8) | 510 (11.5) | 4,246 (10.7) | *0.133* |
| ICU LOS (mean (±SD) days) | 8.5 (±10.5) | 9.8 (±13.3) | 8.4 (±19.9) | *<0.001* |
| Hospital LOS (mean (±SD) days) | 14.1 (±21.0) | 17.5 (±20.0) | 13.7 (±19.9) | *<0.001* |
| Total Hospital Costs (mean (±SD) $) | 107,705 (±153,131) | 182,106 (±263,986) | 99,289 (±132,681) | *<0.001* |

[1]Numbers in parentheses represent percentage (%) except where noted.

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**Table 4**: Baseline Characteristics of Acute Respiratory Failure Tracheostomy Patients cared for in Academic Medical Centers comparing High- and Low-Resource Intensity Environments[1]

| | High RI (n=510) | Low RI (n=4,266) | *p-value* |
|---|---|---|---|
| Age (mean (±SD) years) | 64.6 (±17.2) | 59.9 (±15.9) | *<0.001* |
| Male Gender | 243 (47.8) | 2,231 (52.3) | *0.061* |
| Race | | | *<0.001* |
| *Caucasian* | 256 (50.3) | 2,611 (61.2) | |
| *African American* | 111 (21.8) | 1,122 (26.3) | |
| *Hispanic* | 46 (9.0) | 158 (3.7) | |
| *Other* | 96 (18.8) | 371 (8.7) | |
| Admission status | | | *<0.001* |
| *Emergency* | 350 (68.6) | 2,755 (64.6) | |
| *Urgent* | 119 (23.3) | 1,220 (28.6) | |
| *Elective* | 18 (3.5) | 226 (5.3) | |
| *Other (NA)* | 23 (4.5) | 60 (1.4) | |
| Comorbid conditions | | | |
| *AIDS* | 6 (1.2) | 38 (0.9) | *0.778* |
| *Anemia* | 147 (28.8) | 1,394 (32.7) | *0.084* |
| *Chronic pulmonary disease* | 198 (38.8) | 1,974 (46.3) | *0.002* |
| *Coagulopathy* | 76 (14.9) | 657 (15.4) | *0.796* |
| *Collagen vascular disease* | 22 (4.3) | 132 (3.1) | *0.17* |
| *Congestive Heart Failure* | 179 (35.1) | 1,505 (35.3) | *0.95* |
| *Diabetes* | 109 (21.4) | 1,288 (30.2) | *<0.001* |
| *Fluid and electrolyte disorders* | 259 (50.8) | 2,546 (59.7) | *<0.001* |
| *Hypertension* | 228 (44.9) | 2,073 (48.6) | *0.116* |
| *Hypothyroidism* | 38 (7.4) | 375 (8.8) | *0.342* |
| *Liver disease* | 23 (4.5) | 196 (4.6) | *0.889* |
| *Malignancy* | 90 (17.6) | 367 (8.6) | *<0.001* |
| *Neurological disorder* | 137 (26.9) | 1,079 (25.3) | *0.482* |
| *Peptic ulcer disease* | 2 (0.4) | 17 (0.4) | *0.792* |
| *Peripheral vascular disease* | 22 (4.3) | 188 (4.4) | *0.994* |
| *Psychiatric disorder (depression, psychoses)* | 59 (11.6) | 657 (15.4) | *0.024* |
| *Pulmonary vascular disease* | 48 (9.4) | 447 (10.5) | *0.503* |
| *Renal failure* | 79 (15.5) | 695 (16.3) | *0.669* |
| *Valvular heart disease* | 52 (10.2) | 375 (8.8) | *0.323* |
| *Weight loss* | 84 (16.5) | 947 (22.2) | *0.004* |
| Payer source (%) | | | *0.198* |
| *Commercial insurance* | 108 (21.2) | 810 (19.0) | |
| *Medicare* | 281 (55.1) | 2,252 (52.8) | |
| *Medicaid* | 84 (16.5) | 836 (19.6) | |
| *Other* | 37 (7.2) | 367 (8.6) | |

[1]Numbers in parentheses represent percentage (%) except where noted.

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**Table 5**: Univariate Analysis and Odds Ratios (95% Confidence Interval) for Variables included in Logistic Regression Model for Mortality

| Variable[1] | Univariate analysis[2] | | | Multivariable analysis | |
|---|---|---|---|---|---|
| | Non-survivor (n=11,798) | Survivor (n=32,326) | *p-value* | OR (95% CI) | |
| Complications (≥1) | 1,439 (12.2) | 4,368 (13.5) | *<0.001* | 1.183 | (1.098, 1.275) |
| High RI environment[3] | 1,357 (11.5) | 3,073 (9.5) | *<0.001* | 1.114 | (1.049, 1.763) |
| Tracheostomy X High RI environment[3] | 165 (1.4) | 453 (1.4) | *0.875* | 1.104 | (1.040, 1.168) |
| Expected Death Rate (mean % (±SD)) | 37.5 (±20.0) | 23.8 (±14.4) | *<0.001* | 1.033 | (1.031, 1.035) |
| Age (mean (±SD)(years)) | 65.3 (±21.7) | 59.9 (±17.9) | *<0.001* | 1.012 | (1.010, 1.014) |
| ICU LOS (mean (±SD) days) | 9.0 (±12.3) | 8.4 (±10.9) | *<0.001* | 1.007 | (1.004, 1.009) |
| Non-ICU LOS (mean (±SD) days) | 3.0 (±11.4) | 6.5 (±11.7) | *<0.001* | 0.927 | (0.923, 0.932) |
| Admission status (emergent, non-emergent) | 8,223 (69.7) | 23,684 (73.2) | *<0.001* | 0.907 | (0.858, 0.958) |
| *Comorbid Conditions* | | | | | |
| Solid tumor with metastasis | 1,392 (11.8) | 906 (2.8) | *<0.001* | 2.183 | (1.976, 2.413) |
| Coagulopathy | 2,159 (18.3) | 2,880 (8.9) | *<0.001* | 1.483 | (1.382, 1.591) |
| Solid tumor without metastasis | 802 (6.8) | 1,229 (3.8) | *<0.001* | 1.447 | (1.307, 1.603) |
| Liver disease | 932 (7.9) | 1,585 (4.9) | *<0.001* | 1.422 | (1.289, 1.570) |
| Lymphoma | 354 (3.0) | 388 (1.2) | *<0.001* | 1.440 | (1.221, 1.697) |
| Rheumatoid arthritis/collagen vascular disease | 460 (3.9) | 971 (3.0) | *<0.001* | 1.359 | (1.196, 1.543) |
| Fluid and electrolyte abnormality | 6,335 (53.7) | 14,140 (43.7) | *<0.001* | 1.137 | (1.082, 1.196) |
| Renal failure | 2,218 (18.8) | 5,597 (17.3) | *<0.001* | 1.142 | (1.069, 1.220) |
| Paralysis | 448 (3.8) | 1,650 (5.1) | *<0.001* | 0.870 | (0.777, 0.973) |
| Congestive Heart Failure | 4,070 (34.5) | 11,907 (36.8) | *<0.001* | 0.867 | (0.821, 0.916) |
| Obesity | 743 (6.3) | 3,656 (11.3) | *<0.001* | 0.839 | (0.767, 0.918) |
| Alcohol abuse | 755 (6.4) | 3,170 (9.8) | *<0.001* | 0.825 | (0.752, 0.905) |
| Deficiency Anemias | 2,394 (20.3) | 8,541 (26.4) | *<0.001* | 0.748 | (0.705, 0.792) |
| Depression | 708 (6.0) | 3,494 (10.8) | *<0.001* | 0.75 | (0.685, 0.821) |
| Hypertension | 5,403 (45.8) | 17,795 (55.0) | *<0.001* | 0.745 | (0.706, 0.785) |
| Drug abuse | 365 (3.1) | 2,847 (8.8) | *<0.001* | 0.644 | (0.583, 0.736) |
| Psychoses | 354 (3.0) | 2,491 (7.7) | *<0.001* | 0.63 | (0.560, 0.709) |
| Chronic pulmonary disease | 4,377 (37.1) | 17,083 (52.8) | *<0.001* | 0.628 | (0.597, 0.661) |
| Payer Source (Medicaid) | 1,380 (11.7) | 4,885 (15.1) | *<0.001* | 1.043 | (0.970, 1.122) |
| Tracheostomy | 979 (8.3) | 3,785 (11.7) | *<0.001* | 0.991 | (0.919, 1.063) |
| Gender (female) | 5,568 (47.2) | 15,919 (49.2) | *<0.001* | 0.972 | (0.924, 1.022) |
| Race (non-Caucasian) | 4,613 (39.1) | 13,880 (42.9) | *<0.001* | 0.961 | (0.912, 1.012) |
| *Comorbid Conditions* | | | | | |
| Valvular heart disease | 1,226 (10.4) | 2,912 (9.0) | *<0.001* | 1.003 | (0.925, 1.086) |
| Diabetes (without complications) | 2,667 (22.6) | 8,218 (25.4) | *<0.001* | 0.951 | (0.897, 1.008) |
| Chronic blood loss anemia | 189 (1.6) | 421 (1.3) | *0.013* | 0.949 | (0.791, 1.138) |
| Diabetes (with complications) | 519 (4.4) | 1,714 (5.3) | *<0.001* | 0.938 | (0.838, 1.049) |

[1]Variables significant in multivariable model are listed above hatched line; non-significant variables are presented below hatched line.
[2]Numbers in parentheses represent percentage (%) except where noted.
[3]RI - resource intensity.

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**Table 6**: Outcomes for Acute Respiratory Failure Tracheostomy Patients cared for in Academic Medical Centers comparing High- and Low-Resource Intensity environments[1]

| | High RI (n=510) | Low RI (n=4,266) | *p-value* |
|---|---|---|---|
| Complications (%) | 313 (61.4) | 2,585 (60.6) | *0.786* |
| Mortality (%) | 136 (26.7) | 849 (19.9) | *<0.001* |
| ICU LOS (mean (±SD) days) | 28.1 (±26.4) | 23.9 (±18.8) | *0.037* |
| Hospital LOS (mean (±SD) days) | 44.8 (±38.1) | 35.6 (±30.5) | *<0.001* |
| Total Hospital Costs (mean (±SD) $) | 166,567 (±145,410) | 95,972 (±78,557) | *<0.001* |
| Discharge destination (survivors, %) | | | *0.057* |
| *Home (outpatient care)* | 96 (18.9) | 1041 (24.4) | |
| *Hospice* | 4 (0.8) | 64 (1.5) | |
| *Inpatient setting (acute care hospital, rehab, SNF, etc.)* | 406 (79.7) | 3123 (73.2) | |
| *NA* | 2 (0.5) | 34 (0.8) | |

[1]Numbers in parentheses represent percentage (%) except where noted.