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Variation in mortality rates after admission to long-term acute care hospitals for ventilator weaning

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Abstract

Purpose—We sought to examine variation in long-term acute care hospital (LTACH) quality based on 90-day in-hospital mortality for patients admitted for weaning from mechanical ventilation.

Methods—We developed an administrative risk-adjustment model using data from Medicare claims. We validated the administrative model against a clinical model using data from LTACHs participating in a 2002 to 2003 clinical registry. We then used our validated administrative model to assess national variation in 90-day in-hospital mortality rates in LTACHs from 2013.

Results—The administrative risk-adjustment model was derived using data from 9,447 patients admitted to 221 LTACHs in 2003. The model had good discrimination (C statistic=0.72) and calibration. Compared to a clinically derived model using data from 1,163 patients admitted to 14 LTACHs, the administrative model generated similar performance estimates. National variation in risk-adjusted mortality was assessed using data from 20,453 patients admitted to 380 LTACHs in 2013. LTACH-specific risk-adjusted mortality rates varied from 8.4% to 48.1% (median: 24.2%, interquartile range: 19.7% – 30.7%).

Conclusions—LTACHs vary widely in mortality rates, underscoring the need to better understand the sources of this variation and improve the quality of care for patients requiring long-term ventilator weaning.

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Keywords

Intensive care; critical care; chronic critical illness; mechanical ventilation; hospitals

INTRODUCTION

Approximately 10% of critically ill patients develop persistent organ failures necessitating prolonged organ support, a condition known as chronic critical illness [1]. Chronic critical illness places an extraordinarily large burden on the health system. According to recent estimates approximately 380,000 patients in the United States develop chronic critical illness each year, accounting for over \$26 billion in annual hospital spending [2]. Long-term outcomes for these patients are extremely poor, with only half of patients alive after one year [3–5]. As a consequence, developing novel strategies of care for these patients is a high priority for clinicians, health administrators, and health policy makers [6].

One such strategy is the transfer of patients with chronic critical illness from a traditional short-stay hospital to a long-term acute care hospital (LTACH). LTACHs are specialized facilities that focus on the care of patients with chronic critical illness. Defined by the United States Centers for Medicare and Medicaid services as hospitals with a geometric mean length of stay ≥ 25 days, LTACHs provide holistic medical care and rehabilitation services to patients requiring long-term weaning from mechanical ventilation and those with other types of prolonged acute conditions [7]. Due to favorable reimbursement models and increases in the incidence of chronic critical illness, LTACHs are among the fastest growing segments of acute care in the United States [8]. At last count there were 426 United States LTACHs in operation accounting for over \$5.3 billion in Medicare spending overall [9].

Despite the growing importance of LTACHs in the United States health care system, little is known about them in terms of the quality of care they provide [10,11]. What research exists has focused on the effectiveness of LTACHs compared to other sites of care for chronic critical illness, such as short stay hospitals and skilled nursing facilities [12]. This research generally shows that outcomes after LTACH admission are comparable to outcomes in short stay hospital ICUs [12]. However, extremely little is known about how LTACHs compare to each other in terms of whether or not they vary in the quality of care they provide. Such information is essential to understanding not only the quality of LTACHs but also the quality of care for patients with chronic critical illness in general. To the degree that LTACHs vary in quality, information on care delivery in high-performing LTACHs could be used to develop a set of evidence-based practices that can be used to improve care in other LTACHs.

To better understand this issue, we set out to quantify variation in outcomes across US LTACHs. We focused on patients transferred from short stay hospitals to LTACHs for weaning from mechanical ventilation. Such patients are the archetypal chronic critical illness patients and are the single most common type of patient admitted to LTACHs. Additionally, a focus on weaning from long-term mechanical ventilation is among the most distinguishing features of LTACHs, such that understanding the quality of care for these patients is central to understanding LTACH quality overall.

METHODS

Overview of methodological approach

We used administrative claims data from fee-for-service Medicare beneficiaries to estimate LTACH-specific risk-adjusted 90-day in-hospital mortality rates for patients transferred from short stay hospitals for weaning from mechanical ventilation. We used Medicare data because they are the only national data source for LTACH admissions. We chose 90-day in-hospital mortality as our outcome of interest because it is patient-centered and easily measurable in both administrative and clinical data.

To perform our study in Medicare claims it was first necessary to develop and validate an administrative model suitable for profiling LTACHs on their 90-day in-hospital mortality for ventilated patients. To accomplish this, we developed a novel administrative risk-adjustment model which we then validated by (a) comparing LTACH-specific risk-adjusted mortality rates derived from our administrative model to rates for those same LTACHs derived from a granular clinical dataset; and by (b) examining LTACH-specific risk-adjusted mortality rates derived from our administrative model over time. Under this approach, a valid administrative model would produce similar mortality estimates to a clinical model and would produce mortality estimates that are stable from year to year. This same approach has been successfully applied by Medicare contractors in several other populations [13,14].

Data sources

For our clinical model, we used data from the Ventilation Outcomes Study, a previously published national evaluation of LTACH patient outcomes [15,16]. The Ventilation Outcomes Study database contains detailed demographic and clinical variables on 1,419 ventilated patients admitted to 23 LTACHs across a 12 month period in 2002 and 2003. The data include laboratory values and physiological results from the day of admission as well as in-hospital mortality out to one year from the day of admission. Due to the terms of the data use agreement and to assure reliable risk-adjustment, we restricted the cohort to only LTACHs that consented to allow their de-identified data to be repurposed for this study and that had sufficient case volumes defined as at least 10 patients in the data set, resulting in 1,163 patients from 14 LTACHs.

For our administrative model, we used data from the Medicare Provider Analysis and Review (MedPAR) files. MedPAR contains the final action claims for all hospitalized fee-for-service Medicare beneficiaries in the United States, including hospitalizations at both traditional short stay hospitals and LTACHs. We used MedPAR data from three years: 2003 and 2004 (to approximate the timeframe of the Ventilator Outcomes Study), and 2013 (to approximate a recent year). MedPAR was used to obtain dates of admission and discharge, patient demographics, and International Classification of Diseases—version 9.0—clinical modification (ICD-9-CM) diagnosis and procedure codes for each hospitalization. MedPAR files were linked to the Medicare Healthcare Cost Report Information System (HCRIS) to obtain hospital characteristics. LTACHs and short-stay hospitals were identified using hospital identifiers in HCRIS [17].

Clinical model development

We used data from the Ventilator Outcomes Study to build a robust clinical risk-adjustment model for 90-day risk-adjusted in-hospital mortality. We identified candidate risk-adjustment variables from the list of available elements in the Ventilator Outcomes Study data and prior studies of the clinical factors associated with risk-adjusted outcome in critically ill patients [18,19]. Candidate variables were limited to those collected on the day of LTACH admission and included age, pre-LTACH admission hospital length of stay, co-morbid conditions (congestive heart failure, coronary artery disease, chronic obstructive lung disease, and stroke), vital signs (heart rate, blood pressure, temperature, and respiratory rate), laboratory values (PaO₂, PaCO₂, hematocrit, white blood cell count, creatinine, blood urea nitrogen, sodium, albumin, bilirubin, and glucose), Glasgow coma scale (excluding verbal points since all patients were receiving invasive mechanical ventilation), and 24-hour urine output.

We treated age and pre-hospital length-of-stay as quadratic splines. We categorized continuous variables, other than age and prehospital length-of-stay, based on visual inspection of locally weighted scatterplot smoothing plots and imputed missing variables into the normal category, as previously performed [19]. We treated these variables and other categorical variables as indicator covariates. We then performed step-wise logistic regression based on Akaike's Information Criterion to create a parsimonious model for 90-day risk-adjusted in-hospital mortality [20]. For the final model we examined discrimination using the C-statistic and calibration using the slope and intercept of a fitted plot of observed versus predicted mortality [21].

Lastly, we used hierarchical logistic regression to create hospital-specific risk-adjusted in-hospital mortality rates based upon the final model. To create the risk-adjusted mortality rates we divided hospital-specific predicted mortality (estimated using logistic regression including a hospital-specific random effect) by hospital-specific expected mortality (estimated using logistic regression) and then multiplied by the average mortality in the sample [22]. This approach creates hospital-specific mortality rates that are both *risk-adjusted*, in that they account for variation in base-line risk across hospitals, and *reliability-adjusted*, in that they account for low reliability in small hospitals by moving the estimate toward the population average. This approach is similar to the method that Medicare uses to profile hospitals based on their risk-adjusted mortality [13,14].

Administrative model development

We used MedPAR to build a robust administrative model for 90-day risk-adjusted in-hospital mortality. We identified patients that were transferred from short-stay hospitals to LTACHs for ventilator weaning using a previously validated method [17]. Specifically, we identified mechanical ventilation using ICD-9-CM procedure codes [23] and diagnosis related group codes, and considered patients to be transferred to an LTACH for weaning when there were temporally adjacent admissions at a short stay hospital and at an LTACH, both of which involved mechanical ventilation [17]. To prevent interdependence of observations, for patients with more than one eligible admission within an analysis year, we selected one random admission per year. As in the clinical data set, we limited the analysis to LTACHs with at least 10 admissions within the analysis year. We identified candidate variables from

the set of variables typically available in administrative claims data, specifically focusing on variables found to be associated with long-term mortality in a prior multicenter cohort study [5]. Candidate variables were restricted to those available on the day of LTACH admission and included age, pre-LTACH admission hospital length of stay, co-morbid conditions defined in the manner of Elixhauser using codes from the originating short stay hospital [24], and selected diagnoses and procedures from the originating short stay hospital including coronary artery-bypass grafting, heart valve replacement, shock, thrombocytopenia, traumatic injury, ischemic stroke, and hemorrhagic stroke, all based on ICD-9-CM codes [25].

We treated continuous variables (age and pre-hospital length-of-stay) as quadratic splines. We treated categorical variables (all others) as indicator covariates. We then performed logistic regression to estimate a model for 90-day risk-adjusted in-hospital mortality. We did not perform any variable reduction steps for this model. Instead we retained all covariates hypothesized to be related to mortality in prior work [5]. We examined discrimination using the C-statistic and calibration using the slope and intercept of a fitted plot of observed versus predicted mortality [21].

As with the clinical model, we used hierarchical logistic regression to create hospital-specific risk-adjusted in-hospital mortality based on the administrative model. We separately fit the model in 2003, 2004, and 2013 data, allowing year-specific model covariates and yielding three sets of hospital-specific risk-adjusted mortality rates.

Administrative model validation

We validated our administrative model in two ways. First, we compared risk-adjusted mortality rates from the 2003 clinical model and the 2003 administrative model in the 14 hospitals participating in the Ventilator Outcomes Study using Spearman's rank correlation. We hypothesized that with a valid administrative model the risk-adjusted mortality rates and hospital rankings based on those rates would be similar across the two models. Second, we compared risk-adjusted mortality rates from the 2003 administrative model and the 2004 administrative model for all US LTACHs with data in both years using Spearman's rank correlation. We hypothesized that with a valid administrative model the risk-adjusted mortality rates and hospital rankings based on those rates would be similar across the two years.

Variation in mortality rates across LTACHs

Finally, we used the 2013 risk-adjusted 90-day in-hospital mortality rates from the administrative model as a marker of LTACH performance, examining the variation in risk-adjusted mortality across hospitals. We graphically examined variation using a caterpillar plot in which we plotted each LTACH's risk-adjusted mortality rate against its relative rank. Confidence intervals for the risk adjusted mortality rate were derived using the bootstrap. We also tested the relationship between LTACH-specific risk-adjusted 90-day mortality rates and key hospital characteristics, including ownership status (non-profit, for-profit, or government), co-location status (free-standing or co-located within a short-stay hospital), size (based on total number of beds), and percent of patients receiving mechanical

ventilation (as identified in MedPAR). The goal of this analysis was to provide additional construct validity, since under a valid performance assessment model we would expect performance to vary by key LTACH characteristics [26]. To perform these tests, we compared the mean RAMR across categories using analysis of variance.

All analyses were performed with either SAS 9.2 (SAS Institute, Cary, North Carolina) or Stata 15.0 (StataCorp LLC, College Station, Texas). We considered a p-value of 0.05 to be statistically significant. This work was reviewed and approved by the University of Pittsburgh Human Research Protection Office.

RESULTS

Clinical model

The clinical model was developed in 1,163 patients in 14 hospitals. Of these patients, 239 (20.6%) died in the hospital by day 90. Demographic and clinical characteristics of both survivors and decedents are shown in Supplementary Table S1. The number of patients per hospital ranged from 11 to 280 (median: 53; interquartile range: 30 – 104). Unadjusted 90-day in-hospital mortality across LTACHs ranged from 0.0% to 41.7% (median: 18.2%; interquartile range: 8.0% – 23.9%). The final risk-adjustment model included the following variables: gender, age, short-stay hospital length-of-stay, white blood count, 24-hour urine output, blood urea nitrogen, albumin, glucose, and Glasgow Coma Scale. The full model results are shown in Supplementary Table S2. The model C-statistic was 0.76, the slope of the fitted calibration line was 1.07 ($p=0.41$ for the test that the slope is different than 1.0), and the intercept of the fitted calibration line was -0.01 ($p=0.56$ for the test that the intercept is different than 0). Based on this model, hospital-specific risk-adjusted 90-day in-hospital mortality rates across LTACHs ranged from 12.2% to 41.7% (median: 20.0%; interquartile range: 16.3% – 23.2%).

Administrative model

In the 2003 MedPAR data there were 9,447 eligible patients in 221 LTACHs. Of these patients, 3,283 (34.8%) died in the hospital by day 90. Demographic and clinical characteristics of both survivors and decedents are shown in Table 1. The number of patients per hospital ranged from 10 to 223 (median: 35; interquartile range: 22 – 54). Unadjusted 90-day in-hospital mortality across LTACHs ranged from 0% to 65.2% (median: 30.2%; interquartile range: 20.7% – 42.1%). The full model results are shown in Table 2. The model C-statistic was 0.72, the slope of the fitted calibration line was 1.08 ($p=0.05$ for the test that the slope is different than 1.0), and the intercept of the fitted calibration line was -0.03 ($p=0.08$ for the test that the intercept is different than 0).

Spearman's rank correlation comparing risk-adjusted mortality rates between the clinical model and the 2003 administrative model for the 14 hospitals with estimates from both models was 0.49 ($p=0.08$), suggesting modest correlation (Figure 1). Spearman's rank correlation comparing risk-adjusted mortality rates between the 2003 administrative model and the 2004 administrative model for the 216 hospitals with data in both models was 0.70 ($p<0.001$), suggesting that the administrative model produced results that were stable across

time (Figure 2). Together these analyses suggested that the administrative model produced valid estimates of LTACH performance based on risk-adjusted 90-day in-hospital mortality.

Variation in mortality rates

Hospital-specific risk-adjusted 90-day in-hospital mortality rates for 380 LTACHs in the 2013 MedPAR data are shown in Figure 3. Mortality rates varied widely, ranging from 8.4% to 48.1% (median: 24.2%; interquartile range: 19.7% – 30.7%). Examining risk-adjusted 90-day in-hospital mortality rates across hospital types, we found lower mortality rates among non-profit LTACHs, free-standing LTACHs, and LTACHs with a higher percentage of patients receiving mechanical ventilation compared to a lower proportion (Table 3). There was no significant association between mortality rates and the total bed count or the total number of mechanically ventilated patients.

DISCUSSION

Using a newly-developed and validated administrative risk-adjustment model, we found wide variation in hospital-specific risk-adjusted 90-day in-hospital mortality rates for patients admitted to LTACHs for ventilator weaning. At the best performing LTACH in our sample, only 8.4% of patients were dead at 90 days adjusting for risk and model reliability, while at the worst performing LTACH in our sample 48.1% of patients were dead at 90 days. These findings underscore the need to better understand the sources of this variation and improve the quality of care for patients requiring long-term ventilator weaning in an LTACH setting.

At present there are few evidence-based practices known to be associated with improved survival in long-term ventilator patients. A randomized trial of two weaning strategies found that a strategy of daily trach-collar trials may confer a survival benefit compared to a strategy of titrated pressure support ventilation in LTACHs [27]. However, there are few other studies to guide clinicians that care for long-term ventilator patients, either in the specific processes of care or the overall structure of care. A much larger body of evidence exists for patients receiving mechanical ventilation in acute care ICUs, where numerous care structures or processes are known to be associated with improved clinical outcomes. These include intensivist physician staffing, lower nurse to patient ratios, high nurse education levels, daily interprofessional rounds, daily interruption of continuous sedation, and the use of rounding checklists, among others [28–33]. Whether or not these practices are equally beneficial in the LTACH setting is unknown.

Identifying the best clinical and organizational practices in LTACHs will require a comprehensive and diverse program of comparative effectiveness research [11], including both randomized clinical trials and observational studies [34]. Observational research in LTACHs could take the form of large multi-center cohort studies or positive-deviance studies in which the best-practices at high-performing LTACHs are used to create a performance improvement framework that can be applied at low-performing LTACHs [35]. By quantifying variation in LTACH performance based on risk-adjusted mortality rates, our study provides a valuable starting place for such work.

In addition to quantifying LTACH performance based on risk-adjusted mortality rates, we found that non-profit LTACHs and LTACHs caring for a higher proportion of mechanically ventilated patients demonstrated lower risk-adjusted mortality. The findings about for-profit status mirror the literature in nursing homes, in which for-profit nursing homes generally provide lower quality care compared to non-profit nursing homes [36]. The finding about proportion of mechanically ventilated patients mirrors the literature in acute care ICUs, in which higher volume hospitals generally provide a higher quality of care [37,38]. Although these findings should prompt further investigations into potential mechanisms of action, it is important not to over-interpret them since we cannot rule out the possibility that these factors are just markers for other determinants of performance. We examined the relationship between LTACH characteristics and RAMRs in order to help provide additional construct validity to our performance assessment strategy. Providing definitive evidence of these relationships would require more directed study.

In interpreting our results it is important to consider that outcomes beyond mortality may be of interest when assessing the quality of LTACHs. Other important outcomes may include receipt of evidence-based care processes; physical functioning and emotional well-being among survivors; and a high-quality death among decedents. The latter issue is particularly salient among the LTACH population, since many patients would prefer to avoid high-intensity treatment at the end-of-life, and LTACHs should not be adversely benchmarked for providing end-of-life care. This problem is common to all mortality-based performance assessment and will require future research to solve [39].

It is also important to note that although we quantified variation in LTACH performance, we did not seek to demonstrate performance outliers, i.e. we did not assess whether any one LTACH's performance was statistically significantly different than the average. Although such information can be used to inform hospital choice and is a standard part of United States CMS quality reporting, we did not feel that this approach would provide substantial new insight into variation in performance above our present analyses. Rather, our goal was to demonstrate that variation exists in a way that can help guide LTACH performance improvement, regardless of whether there are statistically significant performance outliers.

Our study has several limitations. The Ventilator Outcomes Study data which we used to validate our administrative model are now over 15 years old, and data were only available for a small number of hospitals, limiting their utility in terms of validation. However, there are no other multi-center clinical datasets in the LTACH population, making these data uniquely valuable for this purpose. Moreover, although we validated our administrative risk-adjustment model, it is likely that some of the variation in risk-adjusted mortality rates we observe are due to unmeasured variation in base-line risk. However, no risk-adjustment model can perfectly account for risk, and model accuracy is similar to other models used to assess hospital performance in administrative data. That said, stronger correlation between our administrative and clinical model would have provided stronger support for the validity of the model. Additionally, we only examined patients transferred to LTACHs for ventilator weaning. In the administrative data set our approach for identifying these patients is unlikely to be perfectly accurate, creating the possibility for bias. And although these patients represent an important demographic in the LTACH population, LTACHs provide care for

many patient that do not receive mechanical ventilation [40]. Our study does not provide insight into LTACH performance for these patients.

Despite these limitations, our study provides an important roadmap for efforts to improve the quality of care in LTACHs and improve outcomes for patients with chronic critical illness. Future work should build off our findings by identifying the clinical and organizational factors common in higher-performing LTACHs and using these to develop a framework for evidence-based health care for patients receiving prolonged mechanical ventilation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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LIST OF ABBREVIATIONS

AIDS	acquired immunodeficiency syndrome
CABG	coronary artery bypass grafting
CI	confidence interval
HCRIS	Healthcare Cost Report Information System
ICD-9-CM	International Classification of Diseases—version 9.0—clinical modification
LTACH	long-term acute care hospital
MedPAR	Medicare Provider Analysis and Review
RAMR	risk-adjusted mortality rates
OR	odds ratio
PTCA	percutaneous transluminal coronary angioplasty
SE	standard error

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HIGHLIGHTS

- Long-term acute care hospitals (LTACHs) are an increasingly common site of care for patients requiring prolonged mechanical ventilation.
- We developed and validated an administrative risk-adjustment model using data from the United States Medicare program.
- LTACH-specific risk-adjusted mortality rates varied from 8.4% to 48.1%.
- Non-profit hospitals and hospitals with a relatively higher percentage of mechanically ventilated patients tended to have lower risk-adjusted mortality rates.
- Future work should attempt to understand the sources of this variation and improve the quality of care for patients requiring long-term ventilator weaning.

Figure 1.

Scatterplot of risk-adjusted mortality rates for the 14 hospitals in the Ventilator Outcomes Study, comparing rates from the clinical model (Y axis) to rates from the administrative model (X axis). Each dot represents one hospital. RAMR = risk-adjusted mortality rate

Figure 2.

Scatterplot of risk-adjusted mortality rates for the 216 hospitals in both the 2003 and 2004 administrative data, comparing rates from the 2004 model (Y axis) to rates from the 2003 model (X axis). Each dot represents one hospital. RAMR = risk-adjusted mortality rate

Figure 3. Caterpillar plot of risk-adjusted mortality rates from the 2013 administrative model. Each long-term acute care hospital is represented as one dot on the plot along with its 95% confidence interval.

Table 1

Demographic and clinical characteristics of patients in the 2003 administrative cohort, by 90-day in-hospital mortality

	All patients (n=9,447)	Survivors (n=6,164)	Decedents (n=3,283)
Age	72.2 ± 11.0	70.7 ± 11.4	75.0 ± 9.7
Male Gender	4,672 (49%)	2,981 (48%)	1,691 (52%)
Short stay hospital length of stay	27.1 ± 16.8	26.7 ± 16.8	27.8 ± 16.9
Short stay procedures and diagnoses			
CABG	742 (8%)	485 (8%)	257 (8%)
Dialysis	473 (5%)	266 (4%)	207 (6%)
Hypotension	660 (7%)	400 (6%)	260 (8%)
PTCA	115 (1%)	72 (1%)	43 (1%)
Hemorrhagic Stroke	264 (3%)	176 (3%)	88 (3%)
Ischemic Stroke	548 (6%)	346 (6%)	202 (6%)
Thrombocytopenia	253 (3%)	182 (3%)	71 (2%)
Trauma	766 (8%)	538 (9%)	228 (7%)
Valve Replacement	345 (4%)	203 (3%)	142 (4%)
Comorbidities			
AIDS	13 (0%)	6 (0%)	7 (0%)
Alcohol abuse	250 (3%)	172 (3%)	78 (2%)
Deficiency Anemias	557 (6%)	375 (6%)	182 (6%)
Rheumatoid arthritis/collagen vas	106 (1%)	70 (1%)	36 (1%)
Chronic blood loss anemia	269 (3%)	156 (3%)	113 (3%)
Congestive heart failure	3,519 (37%)	2,171 (35%)	1,348 (41%)
Chronic pulmonary disease	3,747 (40%)	2,421 (39%)	1,326 (40%)
Coagulopathy	950 (10%)	581 (9%)	369 (11%)
Depression	100 (1%)	80 (1%)	20 (1%)
Diabetes w/o chronic complications	1,004 (11%)	676 (11%)	328 (10%)
Diabetes w/ chronic complications	262 (3%)	159 (3%)	103 (3%)
Drug abuse	67 (1%)	48 (1%)	19 (1%)
Hypertension	2,244 (24%)	1,452 (24%)	792 (24%)
Hypothyroidism	221 (2%)	148 (2%)	73 (2%)
Liver disease	119 (1%)	67 (1%)	52 (2%)
Lymphoma	52 (1%)	25 (0%)	27 (1%)
Fluid and electrolyte disorders	3,722 (39%)	2,384 (39%)	1,338 (41%)
Metastatic cancer	207 (2%)	87 (1%)	120 (4%)
Other neurological disorders	1,107 (12%)	773 (13%)	334 (10%)
Obesity	170 (2%)	136 (2%)	34 (1%)
Paralysis	357 (4%)	291 (5%)	66 (2%)
Peripheral vascular disease	237 (3%)	141 (2%)	96 (3%)
Psychoses	180 (2%)	130 (2%)	50 (2%)
Pulmonary circulation disease	340 (4%)	229 (4%)	111 (3%)

	All patients (n=9,447)	Survivors (n=6,164)	Decedents (n=3,283)
Renal failure	973 (10%)	575 (9%)	398 (12%)
Solid tumor w/out metastasis	178 (2%)	87 (1%)	91 (3%)
Peptic ulcer Disease × bleeding	4 (0%)	3 (0%)	1 (0%)
Valvular disease	882 (9%)	536 (9%)	346 (11%)
Weight loss	1,841 (19%)	1,195 (19%)	646 (20%)

Values are frequency (percent) or mean ± standard deviation

CABG = coronary artery bypass grafting; PTCA = percutaneous transluminal coronary angioplasty; AIDS =acquired immunodeficiency syndrome

Table 2

Results of the administrative risk adjustment model for 90-day in-hospital mortality from the 2003 cohort

	OR	SE	95% CI	T
Male	1.24	(0.06)	[1.13 – 1.36]	4.45
Short stay hospital length of stay (linear spline term)				
10 days	1.02	(0.14)	[0.77 – 1.35]	0.14
10 to 20 days	1.01	(0.05)	[0.92 – 1.11]	0.17
20 to 30 days	1.01	(0.04)	[0.94 – 1.10]	0.34
30+ days	1.00	(0.00)	[0.99 – 1.01]	–0.39
Short stay hospital length of stay (quadratic spline term)				
10 days	1.00	(0.01)	[0.98 – 1.02]	0.00
10 to 20 days	1.00	(0.00)	[0.99 – 1.01]	–0.10
20 to 30 days	1.00	(0.00)	[0.99 – 1.01]	0.09
30+ days	1.00	(0.00)	[1.00 – 1.00]	0.55
Age (linear spline term)				
70	0.99	(0.05)	[0.90 – 1.09]	–0.26
70 to 75	1.02	(0.08)	[0.87 – 1.19]	0.23
75 to 80	1.16	(0.10)	[0.98 – 1.37]	1.70
80+	1.07	(0.03)	[1.02 – 1.13]	2.55
Age (quadratic spline term)				
70	1.00	(0.00)	[1.00 – 1.00]	0.91
70 to 75	1.00	(0.02)	[0.97 – 1.03]	0.15
75 to 80	0.98	(0.02)	[0.95 – 1.01]	–1.09
80+	1.00	(0.00)	[0.99 – 1.00]	–1.17
CABG	0.86	(0.08)	[0.72 – 1.04]	–1.54
PTCA	1.55	(0.17)	[1.25 – 1.92]	3.97
Valve replacement	1.08	(0.23)	[0.72 – 1.63]	0.39
Dialysis	1.28	(0.16)	[0.99 – 1.64]	1.89
Hypotension	1.09	(0.17)	[0.80 – 1.48]	0.55
Thrombocytopenia	1.18	(0.17)	[0.89 – 1.58]	1.16
Trauma	1.16	(0.12)	[0.95 – 1.41]	1.49
Ischemic Stroke	0.81	(0.12)	[0.60 – 1.09]	–1.41
Hemorrhagic Stroke	0.79	(0.07)	[0.66 – 0.95]	–2.58
Comorbidities				
AIDS	4.13	(2.56)	[1.22 – 13.94]	2.28
Alcohol abuse	0.92	(0.14)	[0.68 – 1.24]	–0.55
Deficiency Anemias	0.98	(0.10)	[0.80 – 1.20]	–0.20
Rheumatoid arthritis/collagen vas	1.43	(0.32)	[0.93 – 2.21]	1.62
Chronic blood loss anemia	1.24	(0.17)	[0.95 – 1.62]	1.60
Congestive heart failure	1.16	(0.06)	[1.05 – 1.27]	2.96
Chronic pulmonary disease	1.05	(0.05)	[0.95 – 1.16]	0.99
Coagulopathy	1.10	(0.15)	[0.85 – 1.42]	0.70

	OR	SE	95% CI	T
Depression	0.68	(0.18)	[0.40 – 1.16]	–1.41
Diabetes w/o chronic complications	1.05	(0.08)	[0.90 – 1.23]	0.67
Diabetes w/ chronic complications	1.35	(0.19)	[1.02 – 1.78]	2.13
Drug abuse	1.17	(0.34)	[0.65 – 2.08]	0.52
Hypertension	0.92	(0.07)	[0.80 – 1.06]	–1.13
Hypothyroidism	1.07	(0.17)	[0.78 – 1.46]	0.43
Liver disease	2.04	(0.42)	[1.36 – 3.04]	3.48
Lymphoma	2.26	(0.67)	[1.27 – 4.05]	2.75
Fluid and electrolyte disorders	1.11	(0.05)	[1.00 – 1.22]	2.05
Metastatic cancer	2.84	(0.43)	[2.10 – 3.83]	6.82
Other neurological disorders	0.92	(0.07)	[0.79 – 1.07]	–1.09
Obesity	0.80	(0.17)	[0.53 – 1.21]	–1.06
Paralysis	0.55	(0.08)	[0.41 – 0.73]	–4.01
Peripheral vascular disease	1.32	(0.19)	[0.99 – 1.75]	1.92
Psychoses	1.17	(0.21)	[0.82 – 1.67]	0.87
Pulmonary circulation disease	1.10	(0.14)	[0.86 – 1.41]	0.75
Renal failure	1.37	(0.14)	[1.12 – 1.66]	3.14
Solid tumor w/out metastasis	2.22	(0.36)	[1.61 – 3.05]	4.85
Peptic ulcer Disease × bleeding	0.47	(0.58)	[0.04 – 5.21]	–0.62
Valvular disease	1.16	(0.09)	[0.99 – 1.36]	1.80
Weight loss	1.03	(0.06)	[0.92 – 1.16]	0.57
Constant	0.07	(0.10)	[0.00 – 1.16]	–1.86

OR = odds ratio; SE = standard error; CI = confidence interval; CABG = coronary artery bypass grafting; PTCA = percutaneous transluminal coronary angioplasty; AIDS = acquired immunodeficiency syndrome

Table 3

Relationship between long-term acute care hospital characteristics and risk-adjusted 90-day in-hospital mortality rates for 380 hospitals in the 2013 administrative data.

	Count	Mean (SD)	p-value
Ownership			
Non-profit	65	0.229 (0.079)	0.025
For-profit	301	0.257 (0.074)	
Government	14	0.239 (0.070)	
Co-location status			
Free-standing	123	0.237 (0.074)	0.035
Co-located	179	0.258 (0.074)	
Unknown	78	0.259 (0.077)	
Total Beds			
Quartile 1: 16 – 35	97	0.242 (0.066)	0.530
Quartile 2: 36 – 50	102	0.255 (0.077)	
Quartile 3: 51 – 68	86	0.255 (0.074)	
Quartile 4: 69 – 667	95	0.255 (0.083)	
Count of ventilated patients			
Quartile 1: 10 – 35	98	0.245 (0.065)	0.306
Quartile 2: 36 – 54	92	0.246 (0.075)	
Quartile 3: 55 – 87	95	0.252 (0.083)	
Quartile 4: 88 – 439	95	0.263 (0.078)	
Percent of patients ventilated			
Quartile 1: 0.0243 – 0.1391	95	0.266 (0.071)	<0.001
Quartile 2: 0.1398 – 0.2154	95	0.260 (0.080)	
Quartile 3: 0.2172 – 0.3008	95	0.251 (0.076)	
Quartile 4: 0.3019 – 0.6761	95	0.230 (0.071)	

SD = standard deviation