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Predictors of Early Post-discharge Mortality in Critically Ill Patients: A Retrospective Cohort Study from the California Intensive Care Outcomes Project

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Abstract

Purpose—Existing intensive care unit (ICU) mortality measurement systems address in-hospital mortality only. However, early post-discharge mortality contributes significantly to overall 30-day mortality. Factors associated with early post-discharge mortality are unknown.

Methods—We performed a retrospective study of 8,484 ICU patients. Our primary outcome was early post-discharge mortality: death after hospital discharge and ≤ 30 days from ICU admission. Cox regression models assessed the association between patient, hospital, and utilization factors and the primary outcome.

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Results—In multivariate analyses, the hazard for early post-discharge mortality increased with rising severity of illness and decreased with full code status (HR = 0.33, 95% CI 0.21 to 0.49). Compared to discharges home, early post-discharge mortality was highest for acute care transfers (HR 3.18, 95% CI 2.45 to 4.12). Finally, patients with very short ICU length of stay (< 1 day) had greater early post-discharge mortality (HR 1.86, 95% CI 1.32 to 2.61) than those with longest stays (≥ 7 days).

Conclusions—Early post-discharge mortality is associated with patient preferences (full-code status) and decisions regarding timing and location of discharge. These findings have important implications for anyone attempting to measure or improve ICU performance and who rely upon in-hospital mortality measures to do so.

Keywords

Intensive Care Unit; Hospital Mortality; Patient Discharge; Outcome Assessment (Health Care); Health Services Research

Introduction

Intensive care unit (ICU) quality reporting systems in the United States currently focus exclusively upon in-hospital mortality[1,2] and do not account for deaths that occur soon after discharge, even though 30-day mortality timed from admission (or a procedure) is used for most other conditions.[3,4] Almost 15% of ICU survivors die within 6 months of discharge,[5] and as efforts intensify to reduce the average ICU length of stay (LOS) and in-hospital mortality[1,6] it is conceivable that a significant number of deaths may occur in the early post-discharge period. This is especially relevant given the initiation of public reporting of ICU in-hospital mortality.[1]

Understanding factors associated with early post-discharge mortality has clinical and policy implications. From a clinical perspective, hospitals and physicians often do not receive feedback regarding mortality rates among successfully discharged patients and do not have information about factors that place patients at risk for adverse outcomes after discharge.[7] From a health policy perspective, public reporting of in-hospital mortality may be subject to measurement bias.[8] This would be true if hospitals' patient populations were weighted towards any currently unmeasured patient, hospital, or utilization (e.g., LOS) factor associated with higher or lower risk for early post-discharge mortality.

There has been no prior published research designed to identify factors associated with early post-discharge mortality among survivors after a hospitalization that includes an ICU admission. Some patient characteristics, including severity of illness, have been shown to be associated with in-hospital mortality and may, likewise, be associated with early post-discharge mortality.[9] Similarly, hospital characteristics (e.g., teaching status) may be important.[10,11,12] Finally, utilization decisions, such as discharge location and ICU LOS, may influence whether a patient dies within the hospital or following discharge.[13,8,5]

To assess the relationship between patient, hospital, and key utilization factors and early post-discharge mortality, we examined patients from the California Intensive Care Outcomes (CALICO) project who survived to hospital discharge.

Methods

Hospital Selection

All California hospitals in the United States (N = 308) with at least 50 hospital beds were sent a recruitment packet. Nurses from 35 volunteer hospitals attended a training session, abstracted sample charts, and received feedback on their inter-rater reliability.[12]

Patient Selection

We collected data between 2001 and 2004. Inclusion criteria were age ≥ 18 years and ICU stay ≥ 4 hours.[12] In addition, since CALICO was designed to compare three validated risk adjustment methods, the study only included patients eligible for all risk adjustment models. Therefore, burn, trauma, and coronary bypass graft patients, as well as patients readmitted to the ICU, were not included. Consistent with previous analyses investigating early post-discharge mortality,[14,15] we limited our sample to patients discharged alive from the hospital within 30 days of the first ICU day of a hospitalization. We also specifically chose this timeframe because a 30-day period timed from ICU admission is consistent with quality/mortality reporting of most other conditions or specialties[3,4] that are timed from the onset of the initial exposure. We excluded patients without hospital mortality/LOS information and those without linkable identifiers to the National Death Index (NDI).

Data Collection – Patient, Hospital, and Utilization Characteristics

Characteristics previously shown to be associated with in-hospital mortality or a priori hypothesized to be associated with early post-discharge mortality were organized into related categories, including patient, hospital, and utilization factors.

Patient Factors—Nurses retrospectively abstracted detailed patient-level clinical data on a consecutive sample of patients from each participating hospital.[12] Nurse-collected data included full code status at ICU admission (versus any limitation in care including do not resuscitate [DNR]), admission and discharge times, and in-hospital mortality status. Nurse-collected data also provided the means to estimate patients' severity of illness at ICU admission and anticipated ICU LOS using the Acute Physiology and Chronic Health Evaluation IV (APACHE IV) mortality and LOS models.[9,16] The APACHE IV models account for multiple severity of illness characteristics at ICU admission including age, acute physiology (vital signs and laboratory data), mechanical ventilation, acute diagnoses, chronic diagnoses, medical-surgical status, admission source, and pre-ICU length of stay. APACHE IV models have been previously validated for the CALICO cohort.[12,17] We subsequently divided patients into four clinically meaningful risk categories of predicted in-hospital mortality of very low risk, low risk, moderate risk and high risk. The risk categories correspond to predicted mortality of <1%, ≥ 1% and < 5%, ≥5% and < 10%, and ≥ 10%, respectively.

We obtained patients' demographic information from the California Office of Statewide Health Planning and Development's Patient Discharge Database (OSHPD PDD). Demographic factors included race (white and non-white), gender, and insurance status (private, government insured/Medicare, other).

Hospital Factors—We obtained hospital characteristics from the 2004 American Hospital Association Annual Survey. We included organizational factors that had previously been shown to impact in-hospital mortality and/or discharge practices, and therefore would plausibly be associated with early post-discharge mortality. Factors included in this study were teaching status (membership in the Council of Teaching Hospitals),[11,18] hospital beds,[19,18] hospital ownership (government, private non-profit, private for-profit),[10]

availability of interventional cardiology,[20] and nursing hours per patient day.[21] We report nurse staffing in terms of registered nurse hours per adjusted patient day. This assumes a 40-hour work week and 52 working weeks per year (2080 hours per year). This conversion is accepted as a reasonable approximation.[21,22] We also included the number of medical-surgical ICU beds, a factor associated with intensivist staffing, multidisciplinary rounds,[23] ICU patient volume,[24] volume of mechanically ventilated patients,[25] and ICU utilization patterns.[26] We additionally adjusted for the availability of a palliative care service, given the relevant association with increased mortality outside of the hospital setting.[27]

Hospital and ICU bed size was categorized to reflect small, medium, and large size units. Hospital bed categories included < 150 beds, ≥ 150 and < 300 beds, ≥ 300 beds. ICU bed categories included <10 beds, ≥10 and < 25 beds, and ≥ 25 beds. Hospital volume (annual admission per year) was not included due to high correlation (r = 0.9) with hospital or ICU bed size. Nurse staffing was categorized to reflect low, moderate, and high levels of nursing intensity with: < 6, ≥ 6 and < 10, and ≥ 10 registered nursing hours per adjusted patient day, respectively.

Utilization Factors—Utilization factors included discharge location and observed ICU LOS. ICU LOS was calculated from nursing data and divided into three clinically meaningful categories, those with very short (<1 day), moderate (> 1 and < 7 days), and prolonged (>7 days) ICU LOS. In addition, we calculated a LOS ratio (LOSR) equal to the observed divided by predicted ICU LOS. We determined discharge location from the OSHPD PDD. Discharge locations included four categories: home, another acute care hospital, sub-acute facility (skilled nursing facility or intermediate care), and other (e.g., prison, residential care facility, against medical advice).

Outcome—The primary outcome was early post-discharge mortality, defined as death following hospital discharge and ≤ 30 days from the first ICU day of the index ICU admission.[4,28]

Statistical Analysis

Hospital and Patient Comparisons—We compared CALICO hospital characteristics to all California hospitals. We then compared patient characteristics by early post-discharge mortality status using chi-square and Mann-Whitney tests for categorical and continuous variables, respectively. We additionally compared characteristics among those patients with and without NDI information.

Predictors of Early Post-discharge Mortality—We used Cox regression models to calculate hazard ratios (HRs) for early post-discharge mortality, providing adjustments for standard error estimates based on the sandwich estimator[29] to account for hospital clustering **effect**s. Unadjusted hazard ratios were assessed for each variable within each category (patient, hospital, and utilization). Within each category, predictors were entered into a multivariable model and were selected for the final model through backward selection. Variables were removed from the model at $P > 0.05$. The significant predictors were combined, and pre-specified covariates were added if they had not already been included: race, sex, and patient insurance status. These covariates were included on the basis of the theoretical likelihood that they would be associated with healthcare utilization decisions and outcomes. The proportional hazards assumption was assessed by observing whether the lines were parallel for any comparison using ‘log-log plots.’ The Schoenfeld method was used to test for departure from the assumption that across predictors HRs were constant throughout the period of follow - up.[30]

Sub-group Analysis Excluding High or Low Risk Patients—Because deaths in the early post-discharge period may represent both expected and unexpected outcomes, as a sub-group analysis we repeated the above analyses after excluding those patients with highest likelihood of early post-discharge death: patients transferred to another hospital and patients identified as receiving comfort care at ICU discharge. In addition, because patients with very short lengths of stay and low predicted mortality may be cared for in transitional (or step-down) units in different institutions, we repeated the analyses after excluding patients with an ICU LOS that was less than one day, as well as patients with a predicted risk of in-hospital mortality of < 1%.

Relationship of Patient-level LOS Ratio to Predicted Early Post-discharge Mortality—Next, we assessed whether patients' observed LOS relative to predicted LOS, the standardized length of stay ratio (SLOSR), was associated with early post-discharge mortality. In order to achieve this, we divided the study population into deciles of SLOSR. (The lowest SLOSR decile of patients had the shortest observed LOS compared to predicted) We plotted this against the mean probability of early discharge mortality across each decile and performed a Spearman rank correlation.

Sensitivity Analyses—We assessed the sensitivity of our results to the year of data collection. We also looked at the effect of a variety of LOS intervals on early post-discharge mortality. In addition to the ICU LOS, we examined overall hospital LOS and LOS from ICU discharge to hospital discharge. For each LOS interval, patients were sorted into three clinical categories of short, moderate and prolonged LOS. Next, to more specifically examine the effect of hospital volume, we replaced hospital and ICU bed size with the total number of hospital admissions per year, divided into quartiles. Finally, although continuous patient and utilization risk factors (i.e., predicted in hospital mortality and length of stay) were categorized to reflect meaningful clinical and organizational categories, we further assessed the validity of identified relationships with an alternative categorization strategy (quartiles), as well as treating them as continuous variables. This was repeated for continuous hospital characteristics as well (i.e., hospital beds, medical-surgical ICU beds, hospital volume, and nurse hours per adjusted patient day). All analyses were performed using STATA 9.2 (StataCorp, College Station, TX). The institutional review boards of the University of California, San Francisco and the State of California approved the study.

Results

Hospital Characteristics

Characteristics of the 35 CALICO hospitals were similar to all California hospitals. Full details are published elsewhere.[12] Briefly, 35 participating hospitals included 57% not-for-profit institutions, 29% teaching hospitals, 9% hospitals with <100 licensed beds and 41% >300 licensed beds.

Patient Characteristics

Among the 9,178 patients who met our inclusion criteria, we excluded 647 (7.1%) patients for which NDI data were not available (92% of these did not have social security numbers [SSNs]) and 47 (0.5%) patients with indeterminate mortality data or time of admission/ discharge from the hospital. The final study cohort included 8,484 (90.4% of the original sample) patients. Patient, hospital, and utilization characteristics of the patients are outlined in Table 1 by early post-discharge mortality status. Older, more severely ill, and those not discharged to home were more likely to have an early post-discharge death. Unadjusted ICU LOS was longer for those patients with early post-discharge mortality compared to

survivors. In comparison to the study sample, patients without NDI data (Appendix 1) were younger, more commonly non-white, and uninsured.

Multivariable Associations with Early Post-discharge Mortality

Both patient and hospital characteristics were associated with the hazard of early post-discharge mortality (Table 2). ‘Full code’ patients at the time of ICU admission had reduced hazard, 0.33 (95% CI, 0.21 to 0.49), of early post-discharge death compared to patients not ‘full code.’ Compared to the lowest severity of illness category (< 1% predicted in-hospital mortality), higher mortality risk categories were sequentially associated with increased hazard of early post-discharge death.

Among hospital factors, non-teaching hospitals had higher hazard of early post-discharge death. This was the only examined hospital factor associated with early post-discharge death in the multivariable analysis. Utilization factors were also associated with increased hazard of early post-discharge mortality. Compared to patients with prolonged ICU LOS (≥7 days), those with very short LOS (< 1 day) had 1.86 (95% CI 1.32 to 2.61) increased hazard of early post-discharge mortality. Finally, compared to discharges to home, those discharged to a sub-acute facility or acute care hospital had an increased hazard of early post-discharge mortality, HR 2.71 (95% CI 2.02 to 3.65) and 3.18 (95% CI 2.45 to 4.12), respectively.

Exclusion of Highest and Lowest Risk Patients

After excluding both the highest and lowest risk patients, many of the same factors remained independently associated with the hazard of early post-discharge death (Appendix 2). The only exception was that non-teaching hospitals were no longer at a statistically significant increased hazard of early post-discharge mortality.

Patient-level LOSR and Early Post-discharge Mortality

Figure 1 displays the relationship between SLOSR and the probability of early post-discharge death. The lowest SLOSR decile (observed LOS shorter than expected) had the highest mean probability of early post-discharge death. The correlation between SLOSR decile and probability of early post-discharge death rate was −0.98 (95% CI −0.99 to −0.90).

Sensitivity Analysis

There was no association between the year of data collection and post-discharge mortality. Like ICU LOS, decreasing hospital LOS as well as decreasing LOS from ICU discharge to hospital discharge was associated with increased hazard of early post-discharge mortality. Replacing bed-size with hospital volume did not result in different findings. In addition, analyses with continuous predicted mortality and length of stay or quartiles yielded no significant changes. Early post-discharge mortality continued to increase with increasing severity of illness and decreasing ICU LOS. No significant differences were noted when hospital characteristics were divided into quartiles as well. Alternatively, when hospital variables were analyzed as continuous variables, there was a statistically significant decrease in the hazard of early post-discharge mortality (HR = 0.96, 95% CI 0.93 to 0.99) seen with each additional increase in nurse hour per adjusted day. In this analysis, teaching status was no-longer significant, but all remaining relationships remained almost identical.

Discussion

This is the first study, to our knowledge, to explore risk factors for death early after hospital discharge among ICU survivors. We found that patient, hospital, and utilization factors were independently associated with early post-discharge mortality. We found that short ICU LOS and discharge to locations other than home were associated with increased hazard of early

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post-discharge death. These associations persisted after excluding patients whose early post-discharge deaths were more likely to be expected (transfer patients and those receiving comfort care at ICU discharge). These findings have important implications for anyone attempting to measure or improve ICU performance and who rely upon in-hospital mortality measures to do so.

Among patient factors studied, we observed an association between severity of illness and early post-discharge mortality. This association is intuitive and parallels similar findings in studies exploring factors associated with in-hospital mortality for ICU patients.[31] This likely reflects that although severity of illness improves for all ICU patients from time of presentation to time of discharge, severity of illness at admission is a powerful predictor of severity of illness at discharge. In addition, we observed that ‘full code’ status had a protective effect against early post-discharge death. This observation has been described in prior studies examining in-hospital deaths after ICU discharge,[32] although it has not been consistent across all ICU populations.[33] It is possible that this variable captures some aspect of health status beyond the APACHE IV predicted mortality or that it reflects the direction of health (more likely to be improving than for patients who are DNR). Alternatively, it may represent deficiencies in quality of care among patients that are labeled DNR, but this seems unlikely. Our results do not support a statistically significant impact of race, gender, or insurance status on early post-discharge mortality. Race and gender associations with mortality in prior ICU studies have been mixed,[34,35,36] and race and gender remain important factors to study, given widespread reports of disparities in healthcare. The lack of race or gender associations in our study may reflect our ability to robustly adjust for severity of illness and full code status, both of which have been associated with race.[37,38]

Prior research demonstrates variations in early post-discharge mortality for a variety of conditions and shows that as a result of such deaths, a hospital’s assessment of its performance can be quite different when using in-hospital versus 30-day mortality rates.[8] Among hospital factors, we did not find relationships between early post-discharge mortality and hospital ownership, or bed size, both of which have been associated with in-hospital mortality in other studies.[10] The same relationship was apparent when we replaced bed-size with hospital volume in sensitivity analyses. We did observe that teaching hospitals had decreased hazard of early post-discharge deaths for the entire cohort, although this was no longer apparent for the sensitivity analyses that included nurse staffing as a continuous variable. This may reflect reduced sample size or be confounded by increases in nurse staffing. Prior studies also found lower in-hospital mortality for teaching hospital ICUs, especially if the hospitals are members of the Council of Teaching Hospitals.[11,12] This may indicate variations in quality of care or case mix (or documentation thereof).[11] Our analysis suggests that the teaching hospitals’ lower in-hospital mortality rates extend into the early post-discharge period. Therefore, assessing their performance using in-hospital mortality may under-estimate their mortality performance.

Many have voiced concern regarding the use of in-hospital mortality in performance reporting. A key concern has been that shifting utilization patterns, including increasing discharges to sub-acute facilities and/or shorter lengths of stay, may narrow the window of observation of in-hospital mortality and shift events into the post-discharge period.[39,40,41] In support of this concern, we found that discharges to an acute care hospital or a sub-acute facility were factors strongly associated with early post-discharge mortality. This was true even after excluding patients with highest and lowest probability of death. Therefore, hospitals with more available community resources (such as skilled nursing beds) or a lower threshold to transfer patients may shift mortality to the early post-discharge period.

The effect of shorter ICU LOS on increasing hazard of early post-discharge mortality was also apparent. This suggests there could be an illusory improvement in the in-hospital mortality performance by discharging patients earlier from the hospital. Importantly, we cannot clearly determine the appropriateness of any given patient's LOS. An early post-discharge death with very short LOS may be appropriate in a patient discharged to a skilled nursing facility or home hospice with continued signs of clinical instability, but whose goals have transitioned to comfort care in accordance with the patient's personal wishes. Since the results were unchanged after excluding hospital transfers and/or patients made comfort care at ICU discharge, it is unlikely that all of the post-discharge deaths we observed would have been expected. In addition, we found that LOS that was shorter than predicted (based on severity of illness and LOS patterns for the entire population) was associated with early post-discharge mortality. This suggests that ICU utilization is different than expected yields increased risk of post-discharge death.

Our study has important limitations. First, our volunteer sample, although similar to a diverse group of hospitals in California,[12] may not be generalizable. Another limitation is the inability to link with NDI for 7.1% of the population, which is higher than other California death matches. This is explained by our exclusive use of SSNs to link to NDI because other identifiers were not available. The un-linkable patients we excluded were more likely to be from vulnerable populations (such as undocumented immigrants), and we may have underestimated the true rate of early post-discharge deaths. This limitation is not specific to CALICO and is faced by other 30-day mortality reporting programs that, nonetheless, have been reporting public results for over a decade.[3] In addition, although we selected variables highly relevant to mortality and discharge decisions, in this observational study, important residual confounders that are unmeasured and/or unaccounted for cannot be ruled out. Importantly we lack data about processes of care, complications, and clinical stability at ICU and hospital discharge. These factors may play important roles in explaining early post-discharge deaths. Our observations highlight the need to understand these factors prospectively, given their implications for quality and performance measurement. In addition to variable selection, variable specification may bias observed associations. This is of greatest concern for teaching status, a factor that was no longer significant when applying patient and hospital characteristics as continuous variables. All other associations remained strongly significant with alternative variable specifications. Finally, it is possible that in the evolving arena of critical care, changes in practice behavior and/or new therapies influenced hospitals' performance over the four years of our data collection. However, the addition of a year of admission variable did not alter the results.

Our study suggests that a combination of patient, hospital, and utilization factors are associated with early post-discharge mortality. We found that increases in early post-discharge mortality occurred with decreasing ICU LOS and with discharges to sub-acute facilities. These findings highlight the importance of understanding the characteristics of these early deaths, given that current ICU performance assessments are based on in-hospital mortality rates and may underestimate or overestimate the quality of care. Future research should address how processes of care, patient or physician preferences at the time of discharge, and community resources influence early post-discharge mortality.

Supplementary Material

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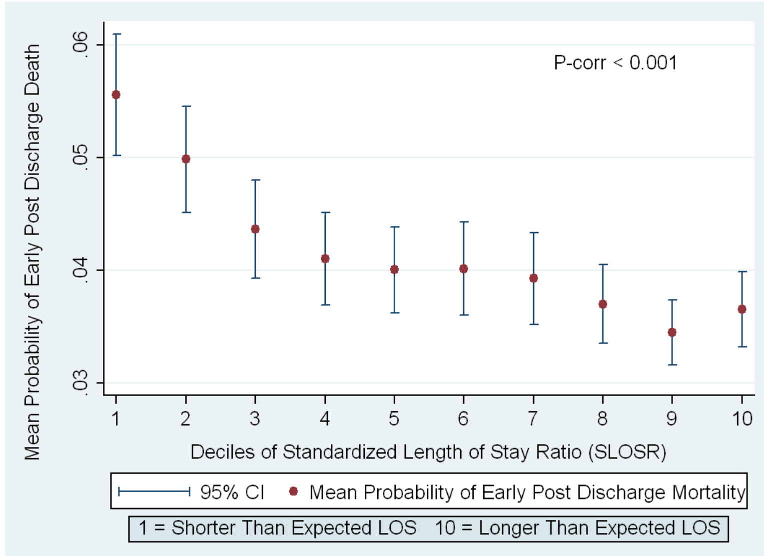

Figure 1.

Relationship between deciles of observed to expected intensive care unit length of stay and adjusted mean probability of early post-discharge mortality. Early post discharge mortality predictions adjusted for the following variables: Age, race gender, code status, severity of illness at ICU admission (predicted in-hospital mortality using APACHE IV), intensive care unit length of stay categories, and discharge location.

Table 1

Patient, Hospital, and Utilization Characteristics

	Early Post-discharge Mortality Among Patients Surviving to Hospital Discharge		
Patient Characteristics	**No (N = 8129)**	**Yes (N = 355)**	**P-Value[a]**
Age, N (%)			< 0.001
18-44	1449 (17.8)	20 (5.6)	
45-64	2944 (36.2)	84 (23.7)	
65-84	3151 (38.8)	181 (51.0)	
85+	585 (7.2)	70 (19.7)	
White race, N (%)	4929 (60.6)	226 (63.7)	0.47
Male gender, N (%)	4362 (53.7)	177 (49.9)	0.16
Full code at ICU[b] admission, N (%)	7901 (97.2)	298 (83.9)	<0.001
Payment source, N (%)			< 0.001
Private	2086 (25.7)	62 (17.5)	
Government insurance, Medicare	3554 (43.7)	209 (58.9)	
None, other, or unknown	2489 (30.6)	84 (23.7)	
Acute diagnoses			
Non-genitourinary sepsis	230 (2.8)	20 (5.6)	0.002
Acute myocardial infarction	753 (9.3)	22 (6.2)	0.05
Bacterial pneumonia	274 (3.4)	28 (7.9)	<0.001
COPD / chronic bronchitis	156 (1.9)	2 (0.6)	0.06
Congestive heart failure	399 (4.9)	31 (8.7)	
Mechanical ventilation at admission	1536 (19.0)	90 (25.4)	0.003
Medical / surgical status at admission			<0.001
Medical	6049 (74.4)	326 (91.8)	
Elective surgical	1747 (21.5)	23 (6.5)	
Emergency surgical	333 (4.1)	6 (1.7)	
Predicted in-hospital mortality at ICU[b] admission[c] (Categories), N (%)			< 0.001
< 1%	1954 (24.0)	13 (3.7)	
≥ 1% and < 5%	3019 (37.1)	54 (15.2)	
≥ 5% and < 10%	1192 (14.7)	59 (16.6)	
≥ 10%	1964 (24.2)	229 (64.5)	
Hospital Characteristics			
Number of hospital beds, median (IQR)	334 (249, 490)	367 (249, 490)	0.76
Hospital bed size categories			0.44
< 150 beds	1536 (18.9)	70 (19.7)	
≥ 150 < 300 beds	2029 (25.0)	78 (22.0)	

	Early Post-discharge Mortality Among Patients Surviving to Hospital Discharge		
Patient Characteristics	**No (N = 8129)**	**Yes (N = 355)**	**P-Value[a]**
≥ 300 beds	4564 (56.1)	207 (58.3)	
Number of medical / surgical ICU beds, median (IQR)	20 (12, 26)	21 (12, 26)	0.83
ICU bed size categories			0.56
< 10 beds	1606 (19.8)	68 (19.2)	
≥ 10 beds < 25 beds	3385 (41.6)	140 (39.4)	
≥ 25 beds	3138 (38.6)	147 (41.4)	
Non-teaching hospital, N (%)	5675 (69.81)	266 (74.9)	0.04
Ownership, N (%)			0.12
Government	2702 (33.2)	100 (28.2)	
Not-for-profit	5126 (63.1)	243 (68.5)	
For-profit	301 (3.7)	12 (3.4)	
Interventional cardiology available	4705 (57.9)	219 (61.7)	0.34
Palliative care service available	2992 (36.8)	130 (36.6)	0.68
Registered nursing hours per adjusted day, Mean (SD)	8.61 (2.5)	8.2 (2.5)	0.004
Registered nursing hours per adjusted day, categories			0.04
< 6	1198 (14.7)	62 (17.5)	
≥ 6 and < 10	3620 (44.5)	172 (48.5)	
≥ 10	3311 (40.7)	121 (34.1)	
Utilization Characteristics	**No (N = 8129)**	**Yes (N = 355)**	**P-Value [a]**
ICU length of stay (days), median (IQR)	1.8 (0.9, 3.4)	2.1 (1.0, 4.1)	0.003
ICU length of stay categories, N (%)			0.06
< 1 day	2242 (27.6)	79 (22.3)	
≥ 1 day < 7 days	5196 (63.9)	239 (67.3)	
≥ 7 days	691 (8.5)	37 (10.4)	
Discharge location, N (%)			< 0.001
Home	5238 (64.4)	114 (32.1)	
Acute care hospital	530 (6.5)	50 (14.1)	
Sub-acute facility	907 (11.2)	115 (32.4)	
Other	1454 (17.9)	76 (21.4)	
Comfort care at ICU discharge	42 (0.5)	39 (11.0)	< 0.001

[a]P-values based on chi-square test of statistical independence for categorical data and Mann-Whitney test for continuous. Totals may not add to 100% due to rounding.

[b]ICU – intensive care unit

[c]Intensive care unit severity of illness – calculated with the Acute Physiology and Chronic Health Evaluation IV mortality prediction model

Table 2

Univariate and Multivariate Cox Models: Patient, Hospital, and Utilization Factors Associated with Early Post-discharge Mortality among All Hospital Survivors(N = 8484)

	Univariate		Multivariate	
Characteristic	**Unadjusted Hazard Ratio**	**95% CI**	**Adjusted Hazard Ratio**	**95% CI**
Patient Characteristic				
Non-white Race	0.88	0.72 to 1.08	0.99	0.82 to 1.19
Male gender	0.86	0.68 to 1.10	1.03	0.81 to 1.31
Full code at admission	0.16	0.11 to 0.24 **	0.33	0.21 to 0.49 **
Insurance type				
Private	1 (Ref)		1 (Ref)	
Government insurance, Medicare	1.95	1.46 to 2.62 **	1.05	0.81 to 1.37
None, other, or unknown	1.13	0.76 to 1.69	1.07	0.78 to 1.47
Predicted in-hospital mortality at ICU[a] admission[b] (Categories), N (%)				
< 1%	1 (Ref.)		1 (Ref.)	
≥ 1% and < 5%	2.67	1.30 to 5.49 *	2.40	1.17 to 4.88 *
≥ 5% and < 10%	7.26	3.69 to 14.3 **	6.05	3.10 to11.8 **
≥ 10%	16.68	9.14 to 30.4 **	12.31	6.80 to 22.3 **
Hospital Characteristic				
Hospital Bed Size				
< 150 beds	1 (Ref.)			
≥ 150 < 300 beds	0.84	0.62 to 1.15		
≥ 300 beds	0.99	0.75 to 1.32		
ICU Bed Size				
< 10 beds	1 (Ref)			
≥ 10 < 25 beds	0.97	0.70 to 1.35		
≥ 25 beds	1.10	0.73 to 1.66		
Non-teaching hospital	1.29	0.98 to 1.69	1.31	1.00 to 1.65 *
Ownership				
Government	1 (Ref)			
Not-for-profit	1.28	0.97 to 1.68		
For-profit	1.07	0.71 to 1.63		
Interventional cardiology available	1.15	0.85 to 1.55		
Palliative care service available	0.97	0.71 to 1.32		
Registered nursing hours per adjusted				

	Univariate		Multivariate	
Characteristic	**Unadjusted Hazard Ratio**	**95% CI**	**Adjusted Hazard Ratio**	**95% CI**
patient day				
< 6	1 (Ref)			
≥ 6 and < 10	0.92	0.67 to 1.25		
≥ 10	0.71	0.56 to 0.90 *		
Utilization Characteristic				
ICU[a] length of stay categories				
< 1 day	0.66	0.48 to 0.90 *	1.86	1.32 to 2.61 **
≥ 1 day < 7 days	0.86	0.63 to 1.17	1.51	1.10 to 2.06 *
≥ 7 days	1 (Ref.)		1 (Ref.)	
Discharge location				
Home	1 (Ref.)		1 (Ref.)	
Outside acute care hospital	4.18	3.17 to 5.52 **	3.18	2.45 to 4.12 **
Sub-acute facility	5.60	4.21 to 7.44 **	2.71	2.02 to 3.65 **
Other or unknown	2.37	1.77 to 3.17 **	1.69	1.25 to 2.27 **

[a]ICU – intensive care unit

[b]Intensive care unit severity of illness – calculated with the Acute Physiology and Chronic Health Evaluation IV mortality prediction model. Prediction model includes variables for age, acute physiology, mechanical ventilation, acute diagnoses, chronic diagnoses, medical-surgical status, admission source, pre-ICU length of stay.

* < 0.05

** < 0.005

Table 3

Multivariate Cox Model Sub-group Analysis: Early Post-discharge Mortality at 30 days among Hospital Survivors after Excluding Patients at Highest and Lowest Risk for Early Post-discharge Mortality

	Excluding Highest Risk Patients[a] N = 7826		**Excluding Lowest Risk Patients[b] N = 5067**	
Characteristic	**Adjusted Hazard Ratio**	**95% CI**	**Adjusted Hazard Ratio**	**95% CI**
Patient Characteristic				
Non-white race	1.07	0.85 to 1.34	1.04	0.80 to 1.37
Male gender	1.14	0.87 to 1.50	1.12	0.85 to 1.48
Full code at admission	0.32	0.19 to 0.55**	0.34	0.22 to 0.53**
Insurance type				
Private	1 (Ref.)		1 (Ref.)	
Government insurance, Medicare	1.03	0.71 to 1.49	0.99	0.74 to 1.33
None, other, or unknown	1.03	0.73 to 1.45	0.92	0.60 to 1.41
Predicted in-hospital mortality at ICU[a] admission[b] (Categories), N (%)				
< 1%	1 (Ref.)		NA	NA
≥ 1% and < 5%	2.56	1.13 to 5.79	1 (Ref.)	
≥ 5% and < 10%	5.80	3.00 to 11.2**	2.19	1.46 to 3.28**
≥ 10%	11.3	6.23 to 20.4**	4.69	3.41 to 6.46**
Hospital Characteristic				
Non-teaching hospital	1.24	0.92 to 1.67	1.16	0.92 to 1.45
Utilization Characteristic				
ICU[c] length of stay categories				
< 1 day	2.21	1.42 to 3.44**	NA	NA
≥ 1 day < 7 days	1.61	1.07 to 2.42*	1.51	1.10 to 2.08*
≥ 7 days	1 (Ref.)		1 (Ref.)	
Discharge location				
Home	1 (Ref.)		1 (Ref.)	
Outside acute care hospital	N/A	N/A	3.79	2.82 to 5.10**
Sub-acute facility	2.78	2.01 to 3.77**	2.71	1.96 to 3.76**
Other or unknown	1.68	1.25 to 2.27**	1.86	1.32 to 2.62**

[a]Excluding acute hospital transfers and comfort care patients at ICU discharge

[b]Excluding patients with an ICU LOS < 1 Day or lowest decile of predicted hospital mortality

[c]ICU – intensive care unit

[d]Intensive care unit severity of illness – calculated with the Acute Physiology and Chronic Health Evaluation IV mortality prediction model. Prediction model includes variables for age, acute physiology, mechanical ventilation, acute diagnoses, chronic diagnoses, medical-surgical status, admission source, pre-ICU length of stay.

*< 0.05

**< 0.005