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Malnutrition, Critical Illness Survivors and post-discharge outcomes: a cohort study

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Abstract

Background—We hypothesized that pre-existing malnutrition in patients who survived critical care would be associated with adverse outcomes following hospital discharge.

Methods—We performed an observational cohort study in one Academic Medical Center in Boston. We studied 23,575 patients, age 18 years, who received critical care between 2004 and 2011 and survived hospitalization.

Results—The exposure of interest was malnutrition determined at ICU admission by a registered dietitian using clinical judgment and on data related to unintentional weight loss, inadequate nutrient intake, and wasting of muscle mass and/or subcutaneous fat. The primary outcome was

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Statement of Authorship

Kris M. Mogensen and Kenneth B. Christopher contributed to the conception and design of the research; Clare M. Horkan and Steven W. Purtle contributed to the design of the research; Kenneth B. Christopher contributed to the analysis of the data; Kris M. Mogensen, Takuhiro Moromizato and James D. Rawn contributed to the acquisition of the data. Kenneth B. Christopher wrote code and contributed to the acquisition, analysis, and interpretation of the data. All authors drafted the manuscript, critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

Patient data is not available to investigators outside of the hospital under study.

90-day post-discharge mortality. Secondary outcome was unplanned 30-day hospital readmission. Adjusted odds ratios were estimated by logistic regression models adjusted for age, race, gender, Deyo-Charlson Index, surgical ICU, sepsis, and acute organ failure. In the cohort, the absolute risk of 90-day post-discharge mortality was 5.9%, 11.7%, 15.8% and 21.9% in patients without malnutrition, those at risk of malnutrition, non-specific malnutrition and protein-energy malnutrition respectively. The odds of 90-day post-discharge mortality in patients at risk of malnutrition, non-specific malnutrition and protein-energy malnutrition fully adjusted were 1.77 (95% CI, 1.23–2.54), 2.51 (95% CI, 1.36–4.62) and 3.72 (95% CI, 2.16–6.39) respectively, relative to patients without malnutrition. Further, the presence of malnutrition is a significant predictor of the odds of unplanned 30-day hospital readmission.

Conclusions—In patients treated with critical care who survive hospitalization, pre-existing malnutrition is a robust predictor of subsequent mortality and unplanned hospital readmission.

Keywords

Malnutrition; critical care; mortality; outcomes; hospital readmission; ICU Survivors

Introduction

Studies demonstrate that malnutrition in the hospitalized patient is underappreciated, is associated with worse outcomes and incurs greater cost than well nourished patients ^{1, 2}. Adverse outcomes in the critically ill are noted with negative energy balance, low creatinine and low body mass index ($< 20 \text{ kg/m}^2$) ^{3–5}. In the critically ill, malnutrition appears to be relatively common and is associated with longer ICU stays and higher rates of complications ⁶. Our group has recently shown that patients diagnosed by a registered dietitian (RD) with malnutrition early in an ICU course have heightened short term mortality ¹.

Patient survival following critical care has increased over time ⁷. Those who survive hospitalization involving an ICU stay have high long-term morbidity, mortality, and healthcare costs after hospital discharge ⁸. The 30-day readmission rate for ICU survivors is nearly 12% and the mortality rate for ICU survivors in the six months following hospital discharge is 15% ^{9, 10}. Decreased functional status, alterations in cognition, neuropsychiatric issues, and lower quality of life are all common features of ICU survivorship ^{11–15}. Identification of ICU survivors at high risk for adverse out-of-hospital outcomes has cost and societal importance ^{9, 16, 17}.

Although short term survival has been explored in critically ill patients with malnutrition, post-discharge outcomes in ICU survivors in these patients is not known. Malnutrition at the time of critical care may be a marker for critical illness survivors who are at high risk for subsequent adverse events. Given the heightened in-hospital mortality in critically ill patients with malnutrition ¹, we sought to determine if malnourished critically ill patients have an increased 90-day mortality following hospital discharge. We hypothesized that patients with malnutrition who survived critical care would have increased risk of post discharge mortality.

Materials and Methods

Source Population

We extracted administrative and laboratory data from individuals admitted to one teaching hospital in Boston, Massachusetts: Brigham and Women's Hospital (BWH), with 777 beds. In addition, data from Massachusetts General Hospital (MGH), with 999 beds, was also included for patients who readmitted to MGH during the study period. The two hospitals, both members of Partners Healthcare, provide primary as well as tertiary care to an ethnically and socioeconomically diverse population within eastern Massachusetts and the surrounding region.

Data Sources

Data on critically ill patients were collected prospectively in a central computerized registry called the Research Patient Data Registry (RPDR)¹⁸ that serves as a central clinical data warehouse for all inpatient and outpatient records at Partners HealthCare sites including BWH and MGH. The RPDR has been used for other clinical research studies and mortality and coding data from the RPDR has been validated¹⁹. Approval for the study was granted by the Partners Human Research Committee Institutional Review Board and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Between 2004 and 2011, there were 23,575 unique patients, age ≥ 18 years, assigned the CPT code 99291 (critical care, first 30–74 minutes)¹⁹ who had nutrition risk assessed at BWH and survived to hospital discharge.

Exposure of Interest and Comorbidities

The exposure of interest has been previously described in detail^{1, 20}. Briefly, RDs screen all ICU patients and those patients deemed at risk for malnutrition are further formally evaluated by an RD using a structured objective assessment. Malnutrition diagnoses are determined by an RD based on prior studies^{21, 22} using clinical judgment and on data related to inadequate nutrient intake of energy and/or protein, wasting of muscle mass and/or subcutaneous fat and unintentional weight loss²⁰. Nutrition diagnoses were categorized *a priori* into malnutrition absent, at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition²⁰. To meet criteria for non-specific malnutrition the patient has known malnutrition risk factors (inadequate nutrient intake of energy, protein, and micronutrients) with metabolic stress and/or overt signs of malnutrition (wasting of muscle mass and/or subcutaneous fat) without supporting anthropometric or biochemical data present. To meet criteria for protein-energy malnutrition, patients must have a combination of disease-related weight loss, underweight status based on percent ideal body weight²³, overt muscle wasting, peripheral edema, inadequate energy or protein intake. Although serum albumin was part of the BWH malnutrition criteria, RDs are trained to consider albumin as an invalid marker of nutritional in patients with significant inflammation, altered volume status, and other conditions where albumin would be reduced as a result of illness. Thus, albumin was used infrequently to classify a patient with malnutrition. Malnutrition was considered to be absent if patients were diagnosed as well nourished and not at risk for malnutrition. We included nutrition data collected by an RD 10 days prior to 2 days after ICU admission.

Race was either self-determined or designated by a patient representative/healthcare proxy. We employed the validated ICD-9 coding algorithms developed by Quan et al ²⁴ to derive a Deyo-Charlson index co-morbidity score to assess the burden of chronic illness for each patient ^{25,26}. Patient type was defined as medical or surgical and incorporates the Diagnostic Related Grouping (DRG) methodology, devised by Centers for Medicare & Medicaid Services ²⁷. Sepsis was defined by ICD-9 codes 038, 995.91, 995.92, or 785.52, three days prior to critical care initiation to seven days after critical care initiation ²⁸. Inotropes or vasopressors were considered to be present if prescribed three days prior to critical care initiation to seven days after critical care initiation ^{1, 16}.

Number of organs with failure was adapted from Martin et al ²⁹ and defined by a combination of ICD-9-CM and CPT codes relating to acute organ dysfunction assigned from three days prior to critical care initiation to 30 days after critical care initiation ³⁰. Noncardiogenic acute respiratory failure was identified by the presence of ICD-9 codes for respiratory failure or pulmonary edema (518.4, 518.5, 518.81, and 518.82) and mechanical ventilation (96.7×), excluding congestive heart failure (428.0–428.9) following hospital admission ³¹. Acute kidney injury was defined as RIFLE class Injury or Failure occurring between three days prior to critical care initiation and seven days after critical care initiation ³². Chronic kidney disease was defined as Stage 3 or higher and determined by the Modification of Diet in Renal Disease (MDRD) equation from the baseline creatinine, age, gender and race of cohort patients ³³. Chronic liver disease was determined by ICD-9-CM codes 571.x, 70.54 and 703.2 at any time prior to discharge ³⁴. To determine socioeconomic disadvantage, we used geocoded residential address data linked to the Area Deprivation Index ³⁵.

End Points

The primary outcome was 90-day post-discharge mortality. Secondary outcomes included unplanned 30-day hospital readmission and discharge to a care facility. Information on vital status for the study cohort was obtained from the Social Security Administration Death Master File which we have validated for in-hospital and out-of-hospital mortality in our administrative database ¹⁹. 100% of the cohort had vital status present at 365 days following hospital discharge. The censoring date was March 15, 2012, and 100% of the cohort had at least 90-day follow-up after hospital discharge. 30-day hospital readmission was determined from RPDR hospital admission data as previously described ⁹ and defined as a subsequent or unscheduled admission to BWH or MGH within 30 days of discharge following the hospitalization associated with the critical care exposure. We excluded readmissions with DRG codes that are commonly associated with planned readmissions in addition to DRGs for transplantation, procedures related to pregnancy, and psychiatric issues ^{9, 36}. Discharge care facility data was determined from hospital records ¹⁶.

Power calculations and statistical analysis

Based on prior studies, ^{1, 9, 16, 17} we assumed that 90-day post-discharge hospital mortality would increase a relative 35% in patients with malnutrition (10.5%) compared to those without malnutrition (7.5%). With an alpha error level of 5% and a power of 80%, the minimum sample size thus required for our primary end point is 2,984 total patients.

Categorical covariates were described by frequency distribution, and compared across nutrition groups using contingency tables and chi-square testing. Continuous covariates were examined graphically and in terms of summary statistics, and compared across exposure groups using one-way ANOVA. Unadjusted associations between nutrition groups and outcomes were estimated by bivariable logistic regression analysis. Adjusted odds ratios were estimated by multivariable logistic regression models with inclusion of covariate terms thought to plausibly interact with both nutrition status and post-discharge hospital mortality. Overall model fit was assessed using the Hosmer-Lemeshow (HL) test. In analyses based on fully adjusted models *P* for interaction was determined to explore for any evidence of effect modification. To evaluate for multicollinearity, we calculated the variance inflation factors and tolerances for each of the independent variables. Further, a multivariable Cox's proportional hazards model was used to illustrate post-discharge survival related to nutritional status.

To reduce potential bias from the nonrandomized assignment of malnutrition, we constructed propensity scores for the allocation of the presence of malnutrition and used these in the primary analysis. Utilizing logistic regression, propensity scores were calculated for each cohort subject to estimate the probability for the presence or absence of malnutrition. Covariate selection for the propensity score development including age, gender, race, Deyo-Charlson index, type (surgical vs. medical), sepsis, acute organ failure, chronic kidney disease, acute kidney injury, non-cardiac acute lung injury, chronic liver disease, congestive heart failure, and vasopressors/inotrope use covariates. Two smaller cohorts were obtained where a patient with malnutrition was matched to a patient without malnutrition on the basis of the propensity score. We utilized Mahalanobis metric matching within calipers defined by the propensity score to match the smaller cohorts³⁷. All *p*-values presented are two-tailed; values below 0.05 were considered nominally significant. All analyses are performed using STATA 13.1MP (College Station, TX).

Results

Patient characteristics of the study cohort were stratified according to 90-day post-discharge mortality (Table 1). In the study cohort, the mean (SD) age at hospital admission was 61.0 (17.8) years. Most patients were male (56.3%), white (76.3%), and had a medically-related DRG (47.1%). 30.7% were discharged to a care facility. In the study cohort, the 30-, 90- and 365-day post-discharge mortality rates were 4.6%, 8.8%, and 16.9%, respectively. Unplanned 30-day post-discharge hospital readmission rate was 16.1%. Age, gender, race, patient type, Deyo-Charlson index, sepsis, vasopressors/inotropes use, acute organ failures, and malnutrition were significantly associated with 90-day post-discharge mortality. Factors that differed between nutrition categories included age, race, patient type, Deyo-Charlson index, sepsis, and acute organ failures (Table 2).

Primary Outcome

Mortality risk in the 90 days after hospital discharge was higher in patients with malnutrition (Figure 1). The odds of 90-day post-discharge mortality in patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.4, 2.4, and 5.0 fold

higher respectively than patients without malnutrition (Table 3). Nutrition status remained a significant predictor of the odds of 90-day post-discharge mortality after adjustment for age, gender, race, Deyo-Charlson index, patient type, sepsis, and acute organ failure. The adjusted odds of 90-day post-discharge mortality in patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.2, 2.0, and 4.0 fold higher, respectively, than patients without malnutrition (Table 3). The adjusted 90-day post-discharge mortality model showed good calibration (HL chi-square 6.70, $P = 0.57$), good discrimination [c-statistic = 0.76 (95% CI, 0.75–0.77)], and there was no multicollinearity as determined by variance inflation factor. Further, the hazard ratio of post-discharge mortality adjusted for age, gender, race, Deyo-Charlson index, patient type, sepsis, and acute organ failure in patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.22 (95% CI, 1.12–1.33), 1.56 (95% CI, 1.45–1.67) and 2.69 (95% CI, 2.41–2.99) respectively relative to patients without malnutrition.

Effect modification is present regarding metastatic malignancy (P -interaction < 0.001), the year of admission (P -interaction < 0.001), patient type (P -interaction < 0.001) and vasopressors/inotropes (P -interaction = 0.036). Individually adding a metastatic malignancy, year, or vasopressors/inotropes term to the final model does not alter the effect size or significance of the malnutrition-90-day post-discharge mortality association (data not shown). While patients with and without metastatic malignancy or vasopressors/inotropes present or those with admission before or after 2005 have different risk estimates, the directionality and significance of the malnutrition-post-discharge mortality association is unchanged. Medical and surgical patients have different risk estimates but have the same directionality and significance of the malnutrition-post-discharge mortality association.

The odds of 30-day readmission in patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.2, 1.5, and 2.1 fold higher, respectively, than patients with malnutrition absent (Table 4). Malnutrition remained a significant predictor of the odds of 30-day readmission following adjustment for age, gender, race, Deyo-Charlson index, patient type, sepsis, and acute organ failure. The adjusted odds of 30-day readmission in patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.1, 1.2, and 1.7 fold higher, respectively, than patients with malnutrition absent (Table 4).

The presence of malnutrition was a strong predictor of discharge to a care facility. The odds of discharge to a care facility in patients with malnutrition present (non-specific or protein-energy malnutrition) was 2.7-fold that of patients with malnutrition absent [OR = 2.67 (95% CI, 2.49–2.87; $P < 0.001$)]. The presence of malnutrition remained a significant predictor of discharge to a care facility after adjustment for age, gender, race, Deyo-Charlson index, patient type, acute organ failure, and sepsis [OR = 2.05 (95% CI, 1.90–2.21); $P < 0.001$] relative to patients with malnutrition absent.

We next assessed the odds of death in a smaller cohort of propensity score matched patients ($n = 7,294$) (Supplemental Table 1). In propensity score matched patients, the unadjusted 90-day post-discharge mortality rates were 16.4% (95% CI, 15.2–17.6) in patients with

malnutrition versus 9.0% (95% CI, 8.2–10.0) in patients at risk for malnutrition or without malnutrition.

The odds of 90-day post-discharge mortality in the group of propensity score matched patients at risk for malnutrition, non-specific malnutrition, or any protein-energy malnutrition were 1.2, 1.8, and 3.5 fold higher respectively than patients without malnutrition (Table 3).

Discussion

In this study, we investigated whether malnutrition early in critical illness in those who survive to hospital discharge was associated with adverse post-discharge outcomes. Our novel observations demonstrate that the presence and severity of malnutrition early in an ICU course is associated with a significant graded increase in the odds of post-discharge hospital mortality. We also demonstrate that patients with malnutrition have increased risk of discharge to a care facility and increased risk of hospital readmission of a magnitude that is clinically significant ³⁸.

ICU survivors are known to have substantial long-term morbidity and mortality ^{8, 10}. Risk factors for adverse events following ICU discharge include comorbidity, severity of illness, organ failure indices, high ICU occupancy, ICU discharge time, and facility type where discharged ⁹. The risk factors for post-hospital death in critical illness survivors are not well known. What our study illustrates is that post-discharge outcomes in critical illness survivors appear to be associated with the presence of malnutrition early in an ICU course. While causation cannot be inferred from an observational study, the malnutrition-post-discharge outcome association has biologic plausibility.

The ideal intervention for improving ICU survivor patients has yet to be identified. Observational studies indicate that sufficient nutrition may play a role in outcome. Adequate protein delivery in the ICU is associated with reduced mortality ³⁹. High-risk groups based on NUTRIC score, odds of mortality is reduced with greater protein and energy delivery ⁴⁰. Patients with a high energy and protein deficit are noted to be less likely to be discharged to home ⁴¹. It is very likely that malnourished patients respond differently to aggressive nutrition intervention than patients who arrive in the ICU nutritionally intact. A single nutrient (e.g., protein alone or a micronutrient alone) is unlikely to have a major impact on ICU outcomes as well as post-discharge ICU outcomes. There is likely a synergistic effect of the correct dose of energy, adequate protein delivery, balance of omega-3 and omega-6 fatty acids, correction of micronutrient deficiencies, and physical therapy to support improved outcomes in the ICU and in the rehabilitation phase ⁴².

The present study may have limitations. Post-discharge outcomes may be influenced by other unmeasured variables independently of malnutrition, which could bias estimates. Ascertainment bias may be present as not all critically ill patients have malnutrition determined, only those considered to be at least at risk. Reliance on ICD-9 codes to determine covariates will underestimate the true incidence or prevalence ⁴³. Despite adjustment for multiple potential confounders, residual confounding may be present and

contribute to observed differences in outcomes. We are not able to adjust for physiologic based severity of illness scores which are strong predictors of critical illness outcome. It is conceivable that inclusion of a physiologic score in the analysis may alter malnutrition-outcome associations. We do utilize the acute organ failure score as a severity of illness adjustor which has similar discrimination for mortality as APACHE II ⁴⁴ (Table 3). However, despite multivariable adjustment, the absence of physiologic data is a potential limitation of our study.

Our study has several strengths. We have ample statistical power to detect a clinically relevant difference in 90-day post-discharge mortality if one exists. A nutritional professional (i.e., an RD) made an in person assessment of nutritional risk of all cohort patients. We have validated the use of CPT code 99291 in a prior study to identify patients in the RDPR dataset who are admitted to an ICU ¹⁹. Finally, the Master Death File accurately captures post discharge mortality in our population ¹⁹.

Conclusion

In aggregate, these data demonstrate that malnutrition is associated with increased post-discharge mortality, hospital readmission and discharge to a care facility. The identification of exposures that are predictive of out-of-hospital outcomes may be useful for targeted interventions. If our observations are corroborated in other cohorts, ICU patients with malnutrition who survive to discharge might benefit from a more intense follow-up schedule and enhanced longitudinal care. Specifically, as malnutrition is potentially modifiable, intensive nutrition support over time following hospital discharge may be a strategy to improve adverse outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Clinical Relevancy Statement

Studies show that critical illness survivors have physical, cognitive, and mental challenges that are associated with adverse outcomes following ICU admission. In our study we find that critical illness survivors who have evidence of malnutrition at ICU admission as determined by registered dietitian assessments have worse post-hospital mortality and readmission. Identification of ICU survivors at high risk for adverse out-of-hospital outcomes has cost and societal importance. The malnourished are high risk group for adverse outcome who can be identified with structured objective assessment by registered dietitians.

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Figure 1. Survival Analysis by Nutrition Status

Note: Unadjusted event rates were calculated with the use of the Kaplan-Meier methods and compared with the use of the log-rank test. Categorization of nutrition status is per the primary analyses. The global comparison log rank p value is <0.001 .

Table 1

Clinical and demographic characteristics of the study cohort (n=23,575)

	Alive at 90-days post-discharge	Expired by 90-days post-discharge	Total	P-value	Unadjusted OR (95%CI) for 90-day post-discharge mortality
	21,508	2,067	23,575		
<i>Age-Mean ± SD</i>	60.1 ± 17.8	70.0 ± 14.9	61.0 ± 17.8	<0.001*	1.04 (1.03, 1.04)
<i>Male Gender-No.(%)</i>	12,176 (57)	1,094 (53)	13,270 (56)	0.001	0.86 (0.79, 0.94)
<i>Non-White Race-No.(%)</i>	5,211 (24)	368 (18)	5,579 (24)	<0.001	0.68 (0.60, 0.76)
<i>Surgical Patient Type-No.(%)</i>	11,637 (54)	760 (37)	12,397 (53)	<0.001	0.49 (0.45, 0.54)
<i>Deyo-Charlson Index-No.(%)</i>				<0.001	
0	10,571 (49)	557 (27)	11,128 (47)		1.00 (Referent)
1-2	7,018 (33)	779 (38)	7,797 (33)		2.11 (1.88, 2.36)
3-6	3,326 (15)	586 (28)	3,912 (17)		3.34 (2.96, 3.78)
7	593 (3)	145 (7)	738 (3)		4.64 (3.80, 5.67)
<i>Acute Organ Failures-No.(%)</i>				<0.001	
0	7,591 (35)	416 (20)	8,007 (34)		1.00 (Referent)
1	7,206 (34)	689 (33)	7,895 (33)		1.75 (1.54, 1.98)
2	4,188 (19)	531 (26)	4,719 (20)		2.31 (2.02, 2.64)
3	1,731 (8)	261 (13)	1,992 (8)		2.75 (2.34, 3.24)
4	792 (4)	170 (8)	962 (4)		3.92 (3.23, 4.75)
<i>Sepsis-No.(%)</i>	1,719 (8)	360 (17)	2,079 (9)	<0.001	2.43 (2.14, 2.75)
<i>Intubation-No.(%)</i>	4,125 (19)	519 (25)	4,644 (20)	<0.001	1.41 (1.27, 1.57)
<i>Non-Cardiac Acute Lung Injury-No.(%)</i>	2,381 (11)	254 (12)	2,635 (11)	0.093	1.13 (0.98, 1.29)
<i>Acute Organ Failure Score-Mean ± SD</i>	8.1 ± 4.4	11.3 ± 4.5	8.4 ± 4.5	<0.001*	1.16 (1.15, 1.17)
<i>Vasopressors/Inotropes-No.(%)</i>	7,480 (35)	610 (30)	8,090 (34)	<0.001	0.79 (0.71, 0.87)
<i>Metastatic Malignancy-No.(%)</i>	5,030 (23)	1,047 (51)	6,077 (26)	<0.001	3.36 (3.07, 3.69)
<i>Acute Kidney Injury-No.(%)</i> ^{††}	1,272 (6)	212 (12)	1,484 (7)	<0.001	1.96 (1.68, 2.29)
<i>Chronic Kidney Disease-No.(%)</i> ^{†††}	5,111 (25)	701 (36)	5,812 (26)	<0.001	1.68 (1.52, 1.85)
<i>Chronic Liver Disease</i>	1,009 (5)	146 (7)	1,155 (5)	<0.001	1.54 (1.29, 1.85)
<i>Area Deprivation Index-Mean ± SD</i>	85.6 ± 24.2	84.0 ± 26.0	85.5 ± 24.4	0.006*	1.00 (1.00, 1.00)

	Alive at 90-days post-discharge	Expired by 90-days post-discharge	Total	P-value	Unadjusted OR (95%CI) for 90-day post-discharge mortality
<i>Days to ICU-Median [IQR]</i>	0 [0, 2]	0 [0, 2]	0 [0, 2]	0.27 [†]	1.02 (1.01, 1.02)
<i>Malnutrition-No. (%)</i>				<0.001	
Absent	16,208 (75)	1,184 (57)	17,392 (74)		1.00 (Referent)
At Risk for Malnutrition	1,906 (9)	195 (9)	2,101 (9)		1.40 (1.19, 1.64)
Non-Specific Malnutrition	2,894 (13)	504 (24)	3,398 (14)		2.38 (2.13, 2.67)
Protein-Energy Malnutrition	500 (2)	184 (9)	684 (3)		5.04 (4.21, 6.03)

Data presented as n (%) unless otherwise indicated. P values determined by chi-square unless designated by (*) then P value determined by ANOVA or (†) then P value determined by Kruskal-Wallis.

^{††} Data available to determine Acute Kidney Injury in 22,286 patients.

^{†††} Data available to determine Chronic Kidney Disease was present in 22,397 patients.

Table 2

Characteristics of the study cohort stratified by Nutrition status

	Malnutrition				P
	Absent	At Risk	Non-Specific	Protein-Energy	
<i>N</i>	17,392	2,101	3,398	684	
<i>Age-Mean ± SD</i>	60.2 ± 18.1	63.2 ± 17.1	63.2 ± 16.9	62.9 ± 15.5	<0.001*
<i>Male Gender-No.(%)</i>	9,776 (56)	1,192 (57)	1,908 (56)	394 (58)	0.868
<i>Non-White Race-No.(%)</i>	4,271 (25)	463 (22)	707 (21)	138 (20)	<0.001
<i>Surgical Patient Type-No.(%)</i>	8,794 (51)	1,127 (54)	2,168 (64)	308 (45)	<0.001
<i>Devo-Charlson Index-No.(%)</i>					<0.001
0	8,612 (50)	914 (44)	1,402 (41)	200 (29)	
1-2	5,553 (32)	766 (36)	1,207 (36)	271 (40)	
3-6	2,722 (16)	359 (17)	660 (19)	171 (25)	
7	505 (3)	62 (3)	129 (4)	42 (6)	
<i>Acute Organ Failures-No.(%)</i>					<0.001
0	7,008 (40)	394 (19)	451 (13)	154 (23)	
1	5,873 (34)	743 (35)	1057 (31)	222 (32)	
2	3,020 (17)	576 (27)	937 (28)	186 (27)	
3	1,066 (6)	253 (12)	588 (17)	85 (12)	
4	425 (2)	135 (6)	365 (11)	37 (5)	
<i>Sepsis-No.(%)</i>	1,153 (7)	221 (11)	578 (17)	127 (19)	<0.001
<i>Intubation-No.(%)</i>	2,296 (13)	799 (38)	1,383 (41)	166 (24)	<0.001
<i>Non-Cardiac Acute Lung Injury-No.(%)</i>	1,339 (8)	452 (22)	739 (22)	105 (15)	<0.001
<i>Acute Organ Failure Score-Mean ± SD</i>	8.0 ± 4.3	9.1 ± 4.5	9.3 ± 4.7	10.2 ± 4.8	<0.001*
<i>Vasopressors/Inotropes-No.(%)</i>	5,415 (31)	849 (40)	1,596 (47)	230 (34)	<0.001
<i>Metastatic Malignancy-No.(%)</i>	4,108 (24)	564 (27)	1,036 (30)	369 (54)	<0.001
<i>Acute Kidney Injury-No.(%)</i> ††	847 (5)	162 (8)	359 (11)	116 (18)	<0.001
<i>Chronic Kidney Disease-No.(%)</i> †††	4,075 (25)	547 (28)	985 (31)	205 (32)	<0.001
<i>Chronic Liver Disease-No.(%)</i>	799 (5)	90 (4)	205 (6)	61 (9)	

	Malnutrition				P
	Absent	At Risk	Non-Specific	Protein-Energy	
<i>Area Deprivation Index-Mean $\pm$ SD</i>	84.5 $\pm$ 25.2	88.1 $\pm$ 21.9	88.8 $\pm$ 21.1	87.2 $\pm$ 21.7	<0.001*
<i>Days to ICU-Median [IQR]</i>	0 [0, 1]	1 [0, 2]	1 [0, 4]	1 [0, 4]	<0.001 [†]
<i>Discharge to Care Facility-No.(%)</i>	4,393 (25)	899 (43)	1,659 (49)	279 (41)	<0.001
<i>30-day Readmission-No.(%)</i>	2,572 (14.8)	362 (17.2)	694 (20.4)	182 (26.6)	<0.001
<i>Post Discharge Mortality-No.(%)</i>					
90 days	1,184 (6.8)	195 (9.3)	504 (14.8)	184 (26.9)	<0.001
365 days	2,373 (13.6)	398 (18.9)	901 (26.5)	309 (45.2)	<0.001

Data presented as n (%) unless otherwise indicated. P values determined by chi-square unless designated by (*) then P value determined by ANOVA or ([†]) then P value determined by Kruskal-Wallis.

^{††}Data available to determine Acute Kidney Injury in 22,286 patients.

^{†††}Data available to determine Chronic Kidney Disease was present in 22,397 patients.

Table 3

Unadjusted and Adjusted associations between Nutrition status and post-discharge mortality

Mortality Odds Ratio (95% CI) ^a				
	Malnutrition			
	Absent	At Risk for Malnutrition	Non-Specific Malnutrition	Protein-Energy Malnutrition
<i>90-day post discharge mortality</i>				
Crude	1.00 (Referent)	1.40 (1.19, 1.64)	2.38 (2.13, 2.67)	5.04 (4.21, 6.03)
Adjusted ^b	1.00 (Referent)	1.14 (0.97, 1.35)	1.96 (1.74, 2.21)	3.93 (3.25, 4.76)
Adjusted ^c	1.00 (Referent)	1.20 (1.02, 1.41)	2.04 (1.82, 2.29)	3.99 (3.31, 4.81)
Propensity Score Matched ^d	1.00 (Referent)	1.15 (0.85, 1.56)	1.75 (1.49, 2.05)	3.52 (2.83, 4.39)
<i>365-day post discharge mortality</i>				
Crude	1.00 (Referent)	1.48 (1.32, 1.66)	2.28 (2.09, 2.49)	5.22 (4.46, 6.10)
Adjusted ^b	1.00 (Referent)	1.24 (1.10, 1.41)	1.90 (1.73, 2.09)	4.24 (3.59, 5.01)
Adjusted ^c	1.00 (Referent)	1.30 (1.15, 1.47)	2.02 (1.84, 2.21)	4.36 (3.71, 5.14)
Propensity Score Matched ^d	1.00 (Referent)	1.14 (0.90, 1.44)	1.70 (1.50, 1.92)	3.75 (3.11, 4.51)

Note:

^aReferent in each case is absence of malnutrition.^bEstimates adjusted for age, gender, race, Deyo-Charlson index, type (surgical vs. medical), sepsis, and acute organ failure^cEstimates adjusted for gender, and the acute organ failure score^dPropensity Matched cohort (n=7,294), matched for age, gender, race, Deyo-Charlson index, type (surgical vs. medical), sepsis, acute organ failure, chronic kidney disease, acute kidney injury, non-cardiac acute lung injury, chronic liver disease, congestive heart failure and vasopressors/inotrope use.

Table 4

Unadjusted and Adjusted associations between Nutrition status and 30-day Readmission

30-day Readmission Odds Ratio (95% CI)^a				
	Malnutrition			
	Absent	At Risk for Malnutrition	Non-Specific Malnutrition	Protein-Energy Malnutrition
<i>30-day readmission</i>				
Crude	1.00 (Referent)	1.20 (1.06, 1.35)	1.48 (1.35, 1.62)	2.09 (1.75, 2.49)
Adjusted ^b	1.00 (Referent)	1.05 (0.93, 1.18)	1.20 (1.09, 1.32)	1.74 (1.46, 2.08)
Adjusted ^c	1.00 (Referent)	1.17 (1.03, 1.32)	1.44 (1.31, 1.58)	1.98 (1.66, 2.36)
Propensity Score Matched ^d	1.00 (Referent)	1.08 (0.85, 1.37)	1.20 (1.05, 1.36)	1.67 (1.36, 2.04)

Note:

^aReferent in each case is absence of malnutrition.^bEstimates adjusted for age, gender, race, Deyo-Charlson index, type (surgical vs. medical), sepsis, and acute organ failure^cEstimates adjusted for gender, and the acute organ failure score^dPropensity Matched cohort (n=7,294), matched for age, gender, race, Deyo-Charlson index, type (surgical vs. medical), sepsis, acute organ failure, chronic kidney disease, acute kidney injury, non-cardiac acute lung injury, chronic liver disease, congestive heart failure and vasopressors/inotrope use.