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Derivation of Data-Driven Triggers for Palliative Care Consultation in Critically Ill Patients

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Abstract

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Purpose—To examine the ability of existing triggers for intensive care unit (ICU) palliative care consultation to predict 6-month mortality, and derive new triggers for consultation based on risk factors for 6-month mortality.

Materials and Methods—Retrospective cohort study of NY state residents who received intensive care, 2008–2013. We examined sensitivity and specificity of existing triggers for predicting 6-month mortality and used logistic regression to generate patient subgroups at high-risk for 6-month mortality as potential novel triggers for ICU palliative care consultation.

Results—Of 1,019,849 patients, 195,847 (19.2%) died within 6 months of admission. Existing triggers were specific but not sensitive for predicting 6-month mortality, (sensitivity 0.3%–11.1%, specificity 96.5–99.9% for individual triggers). Using logistic regression, patient subgroups with the highest predicted probability of 6-month mortality were older patients admitted with sepsis (age 70–79 probability 49.7%, [49.5–50.0]) or cancer (non-metastatic cancer, age 70–79 probability 51.5%, [51.1–51.9]; metastatic cancer, age 70–79 probability 60.3%, [59.9–60.6]). Sensitivity and specificity of novel triggers ranged from 0.05% to 9.2% and 98.6% to 99.9%, respectively.

Conclusions—Existing triggers for palliative care consultation are specific, but insensitive for 6-month mortality. Using a data-driven approach to derive novel triggers may identify subgroups of patients at high-risk of 6-month mortality.

Keywords

Critical illness; palliative care; intensive care units; sepsis; neoplasms

Integration of specialized palliative medicine teams within the intensive care unit (ICU) may potentially improve the value of care in certain patients. Several studies have demonstrated the benefit of specialized palliative care in reducing length of stay, decreasing non-beneficial resource utilization, and increasing use of hospice without sacrificing quality of care [1–3]. Many critically ill patients may benefit from these services, as 14% of all admissions to ICUs within the U.S. meet screening criteria, or triggers, for palliative care consultation [4]. Moreover, many patients who survive critical illness go on to suffer from substantial symptomatology and impairments in quality of life [5–8], and palliative care consultants may be best poised to attend to these needs.

Despite these potential benefits, palliative care consultation in the ICU remains underutilized [9]. Although the use of triggers to identify patients with potential palliative care needs is gaining acceptance, existing triggers for consultation have not been formerly validated. Such “validation” may be difficult secondary to a lack of an accepted definition of palliative care need, as well as a lack of consensus regarding when palliative care should be used. However, in the past decade, two states (California and New York) have enacted laws mandating that physicians discuss end-of-life care options for patients who are likely to die within six months [10–12]. Traditionally tied to the initiation of the hospice benefit, 6-month mortality represents a concrete, objective and measurable outcome that is likely to be associated with substantial palliative care need. While palliative care is appropriate for patients with serious illness and need not be tied to a terminal condition, demonstrating existing triggers ability to predict long-term mortality may increase adoption of such methods to deliver palliative care

to critically ill patients. Therefore, we had two primary aims in this study: to examine the ability of existing triggers for palliative care consultation to predict 6-month mortality and 2) to derive novel “data-driven” triggers from demographic and clinical characteristics, based on an ability to predict 6-month mortality.

Methods

Patients and Data Collection

The study protocol was reviewed and approved by the institutional review board of Columbia University Medical Center (IRB-AAAJ2158 New York, NY). Written informed consent was waived. Data for this study came from the New York Statewide Planning and Research Cooperative System (SPARCS) for the years 2008 – 2013. SPARCS is a comprehensive data reporting system that collects patient-level data including patient characteristics, diagnoses and treatments, services, and charges for every hospital discharge in New York State (NY). Data from SPARCS were also linked to NY State and New York City Vital Records to obtain 6-month mortality data for all patients. The cohort consisted of all patients over the age of 18 with an acute care hospitalization with admission to an ICU (defined by ICU bed utilization billing codes). As we did not have data regarding deaths and rehospitalizations occurring outside the state, we excluded patients with a primary residence outside of NY [13].

Patient-level covariates available for inclusion in regression models were age, gender, race (White, Black, and other), insurance (private, Medicare, Medicaid, self-pay, other), type of patient (non-surgical, surgical) and number of Elixhauser comorbidities [14]. We also examined all specific Elixhauser comorbidities, as well as the top ten diagnoses and procedures associated with the highest rates of dying within 6 months.

We identified existing triggers for palliative care consultation in the ICU that were available in the SPARCS database (age > 80 with two or more life-threatening comorbidities, active stage IV malignancy, status post cardiac arrest, intracerebral hemorrhage requiring mechanical ventilation, global cerebral ischemia, multi-system organ failure and advanced stage dementia; for detailed definitions, see additional methods in the supplementary material) [4]. We excluded seven objective triggers (ICU admission after hospital stay > 10 days, ICU stay > 1 month, Glasgow Coma Score (GCS)=3, GCS < 8 for > 1 week in a patient age > 75 years, > 3 ICU admissions during the same hospital stay, mechanical ventilation > 7 days, ICU length of stay > 50% of average) that could not be identified using variables in the SPARCS database [15].

Statistical Analysis

We summarized demographic and clinical characteristics for the cohort, stratified by 6-month mortality. We assessed the association of each existing trigger with 6-month mortality by calculating sensitivity, specificity and area under the receiver operating characteristics curve (AUC).

For the purposes of deriving novel triggers, we randomly divided the cohort into derivation and validation subsets. We also summarized demographic and clinical characteristics for

these derivation and validation cohorts. To derive novel triggers for palliative care consultation, we generated a logistic regression model with mortality occurring within 6 months of the admission date of the hospitalization that required ICU care as the primary outcome. In this model, we included age, gender, race and insurance, as well as other variables (listed above) that had a standardized difference in 6-month mortality greater than 0.2 [16]. Cluster-robust standard errors were used to adjust for clustering by hospital [17]. We identified conditions strongly associated with 6-month mortality (defined as variables with an odds ratio ≥ 2) and combined them with other patient characteristics to create high-risk subgroups [18]. We then used the model to generate the predicted probability of dying within 6 months of hospital admission for these subgroups to create novel palliative care triggers for use on ICU admission.

For all covariates, no covariate was missing for more than 1% of patients. Patients missing data for particular covariates were handled using listwise deletion in regression analyses. Model discrimination was assessed using the AUC, and overall model fit was assessed using the Brier score, as the Hosmer-Lemeshow goodness-of-fit test may perform poorly in large sample sizes [19, 20]. Multi-collinearity between covariates was assessed using variance inflation factor and tolerance values [21].

Secondary analyses

As a secondary confirmatory analysis, we used a recursive partitioning model to identify combinations of patient characteristics predictive of 6-month mortality (see supplementary material for further details). Also, given that survivors of critical illness go on to have substantial morbidity and mortality [5–8, 22], we created another model to derive novel triggers for use upon ICU discharge to determine if additional patient subgroups could be identified. For this model, we excluded patients who died during hospitalization or those who were discharged to hospice, and the outcome was dying within 6 months of discharge from the hospitalization requiring ICU care. We included all variables from the initial “admission” model, as well as variables related to the care delivered during hospitalization and discharge (for further details, see supplementary material). We then used the same methodology enumerated above to generate patient subgroups with a high predicted probability of dying within 6 months of hospital discharge. Database management and statistical analysis were performed using SAS 9.4 (SAS institute, Cary, NC), Stata 13.1 (StataCorp LP, College Station, Tex) and R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics of the cohort

The cohort consisted of 1,019,849 critically ill patients NY State from 2008–2013, of whom 195,847 (19.2%) died within 6 months of their admission which included receipt of care in an ICU. Patients who died within 6 months were older (73.0 vs 61.6 years), had a higher number of comorbidities (49.8% versus 29.5% for ≥ 4 comorbidities) and were more likely to be non-surgical (45.8% versus 30.8%). Patients who died within 6 months were also more likely to receive mechanical ventilation (45.2% versus 13.2%) and dialysis (8.5% vs. 3.1%),

had longer lengths of hospital stay (8 days interquartile range (IQR) 4–17 versus 6 days, IQR 3–10) and were more likely to be discharged to a location other than home (70.6% versus 18.3%) (Table 1). The derivation cohort consisted of 509,924 patients and the validation cohort consisted of 509,925 patients; baseline characteristics between the derivation and validation cohorts were similar (Table E1 in the supplementary material).

Ability of existing triggers to predict 6-month mortality

Overall, existing triggers had low sensitivity and high specificity for predicting 6-month mortality among ICU patients. Sensitivity for 6-month mortality ranged from 0.3% to 11.1% for specific triggers, and was as high as 32.1% for meeting any trigger. Specificity ranged from 96.5% to 99.9%, and was 92.1% for meeting any trigger, while positive predictive value ranged from 40.2% to 75.8%, and was 49.2% for meeting any trigger. The AUC was non-informative for all triggers, ranging from 0.50 to 0.55 (0.62 for any trigger) (Table 2).

Derivation of novel palliative care consultation triggers

When covariates were evaluated for an association with 6-month mortality using logistic regression, age, metastatic cancer, solid tumor without metastases and weight loss were all strongly associated with 6-month mortality (Table E2 in the supplementary material). For the derivation cohort, the AUC was 0.78 and the Brier score was 0.13, indicating adequate discrimination and overall model fit; these metrics were essentially unchanged for the validation cohort (AUC 0.79, Brier score 0.13). We then combined selected risk factors together to create novel triggers for palliative care consultation. For example, patients who were age 70–79 and admitted with severe sepsis had a 49.7% predicted probability of dying within 6 months (95% Confidence Interval (CI) 49.5–50.0); the probability was increased for patients age ≥ 80 (predicted probability 63.3%, 95% CI 63.1–63.5). Patients age 70–79 with non-metastatic cancer had a predicted probability of 6-month mortality of 51.5% (95% CI 51.1–51.9), while those with metastatic cancer had a predicted probability of 60.3% (95% CI 59.9–60.6) and patients with weight loss had a predicted probability of 45.2% (95% CI 44.8–45.6). All probabilities were increased with increased age (Table 3).

Secondary analyses

The recursive partitioning tree identified 3 variables that significantly predicted 6-month mortality: age ≥ 70, metastatic cancer and sepsis. The tree identified two groups of patients with high likelihood of dying within 6-months, (patients age < 70 with metastatic cancer and patients age ≥ 70 with sepsis), revealing similar groups to those identified by the logistic regression model (Figure E1 in the supplementary material).

Of 903,916 critically ill survivors, 86,094 (9.5%) died within 6 months of hospital discharge. Patients with metastatic and non-metastatic cancer were identified as being high-risk for dying within 6 months of discharge (Table E3 in the supplementary material). Addition of certain variables increased the predicted probability of 6-month mortality (e.g., for cancer patients discharged to a SNF, predicted probability of 6-month mortality 49.9% for non-metastatic cancer, 95% CI (49.4–50.4); 57.0%, 95% CI (56.5–57.5) for metastatic cancer (Table E4 in the supplementary material).

Ability of Novel Triggers to Predict 6-Month Mortality

Novel triggers were similar to existing triggers with regard to their ability to predict 6-month mortality among ICU patients. Sensitivity ranged from 0.05 to 9.2, specificity ranged from 98.6 to 99.9, and positive predictive value ranged from 42.2 to 81.1 (Table E5 in the supplementary material).

Discussion

In a large cohort of critically ill patients in New York State, approximately 1 out of 5 patients died within 6 months of admission, with half of those patients dying during the initial ICU hospitalization. For patients who survived to hospital discharge, 1 out of 10 survivors died within 6 months of hospital discharge. We found that existing triggers were specific, but not sensitive for 6-month mortality, and we were able to generate several novel triggers for palliative care consultation with similar performance metrics. If we only accept triggers with a predicted probability of 6-month mortality of at least 50%, approximately 10% of critically ill patients would meet one or more novel triggers for palliative care consultation.

In deriving novel triggers, we chose 6-month mortality as the outcome, which is currently tied to the initiation of the hospice benefit and not palliative care consultation. However, there is no accepted definition of “palliative care need”, nor is there a consensus regarding the best outcome to measure the effectiveness of various trigger criteria or what constitutes appropriate use of palliative care consultation. Although a high-risk of 6-month mortality is not necessarily equivalent to the need for specialized palliative care, we chose this outcome because it represented a “low-hanging fruit” that is likely to be highly specific for palliative care need, which may facilitate the acceptability of palliative care triggers.

The triggers generated in this study identify older patients with sepsis and cancer, and include patients that may not have been captured by existing triggers. While metastatic malignancy has previously been identified as a trigger, as 6-month mortality for patients with non-metastatic cancer was also high, our findings suggest that differentiating between metastatic and non-metastatic cancer may not be necessary. Moreover, increasing evidence demonstrating the benefit of early involvement of specialized palliative care for patients with cancer led the American Society of Clinical Oncology to publish guidelines in 2016 recommending initiation of palliative care for patients with early and advanced cancer [23–26]. Thus, an admission to the ICU may present an opportunity to connect these patients to palliative care services, which should be provided concurrently with standard oncology care.

Older patients with sepsis were also identified as having a high risk for 6-month mortality. This group, in particular, represents a cohort of individuals who are seen as extremely high risk in the acute setting for death, but few would consider it an indication for palliative care among those who survive the hospitalization; however, our data suggest that initiation of palliative care for these patients at the time of ICU admission may also be reasonable.

Similar to previous triggers, novel triggers were highly specific for 6-month mortality, but as the overall rate of 6-month mortality was only 20%, the positive predictive value of triggers

was much lower. Given that the culture of the ICU is largely one of denying death [27], minimizing false positives may be most important for achieving buy-in from stakeholders who may otherwise be reluctant to initiate palliative care consultation. Moreover, given the current workforce shortage of palliative care specialists [28], the risk of delivering potentially unnecessary palliative care versus the risk of having unmet palliative care needs should be carefully weighed (although 75% of surveyed ICU clinicians believe that palliative care consultation is underutilized [9], suggesting that the potential for unmet palliative care needs may be greater).

Sensitivity was very low for all triggers, indicating that many patients at risk of 6-month mortality may be missed. Additionally, these novel triggers likely represent only a small portion of patients for whom palliative care consultation is appropriate; consults for reasons like complex pain and symptom management, conflict resolution and complex decision-making may be missed if these triggers are used in isolation.

One strength of our study is that the methodology may be used to generate novel triggers in a “personalized” way, as it may be applied to any patient population or used for any outcome. Due in part to the lack of an accepted universal outcome by which to evaluate the success of palliative care consultation [29], it has been suggested that triggers should be population or institution-specific [15]. In particular, evaluating palliative care triggers using patient-centered outcomes like quality of life or concordance between desired and delivered care may be most appropriate [29, 30]. However, as this type of information is not readily collected, implementing measurements of such outcomes in a widespread manner is impractical at this time.

This study has several limitations. As our data source was an administrative dataset, the lack of many potential variables of interest limited the types of triggers that could be evaluated or generated, as well as the choice of outcome. Although we were unable to evaluate the performance of seven existing objective triggers, only one of these triggers (ICU admission after hospital stay ≥ 10 days) accounted for a substantial portion of ICU admissions (5%) in a prior study [4]. Moreover, given that existing triggers were developed using a similar methodology (using expert opinion and chart reviews to identify patients at high-risk of mortality), these “missing” triggers are likely to perform similarly to those that we were able to evaluate. Another limitation is that the novel triggers were based on objective data (e.g. age, length of stay, diagnosis). In a survey study of ICU clinicians’ attitudes towards the use of triggers for palliative care consultation, triggers based on age or length of stay were found to be least palatable, while those based on family needs, conflict and diagnosis were most acceptable, with “metastatic malignancy” being the most acceptable [9]. As the triggers generated in our study combine multiple patient factors together, their acceptability to clinicians is unclear. Moreover, triggers that are most acceptable (and therefore most likely to be used in clinical practice) may not be easily derived from commonly used data sources. We are also unable to account for the use of palliative care consultation in our study, as patient level receipt of palliative care cannot be reliably determined in critically ill patients in administrative data [31]. Lastly, while we tied triggers to an outcome to provide a measure of validity, it remains to be seen whether aligning triggers with prognostic information would modify their acceptability or enhance their use.

In a cohort of critically ill patients, dying within 6 months of the ICU stay was common, and groups at high-risk of death were able to be identified as potential candidates for palliative care consultation. Novel triggers identified older adults with severe sepsis and any type of cancer, two populations that are currently not identified by existing triggers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

ICU	intensive care unit
SPARCS	Statewide Planning and Research Cooperative
GCS	Glasgow Coma Score
AUC	area under the curve

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Highlights

- Existing palliative care triggers are specific for 6-month mortality.
- Older patients with severe sepsis or cancer are at high risk of 6-month mortality.
- These populations may also be appropriate for palliative care consultation.

Table 1

Baseline Characteristics of Critically Ill Patients, Stratified by 6-Month Mortality

	Died Within 6 Months of Admission	
	No (n=842,002)	Yes (n=195,847)
Age, mean (SD)	61.6 (18.2)	73.0 (15.2)
Female, n (%)	387,442 (47.0)	97,211 (49.6)
Race, n (%)		
White	499,596 (60.6)	129,668 (66.2)
Black	125,870 (15.3)	27,802 (14.2)
Other	198,536 (24.1)	38,357 (19.6)
Rural residence, n (%)	82,989 (10.0)	17,047 (8.7)
Insurance, n (%)		
Private	329,883 (40.0)	47,325 (24.2)
Medicare	352,798 (42.8)	127,668 (65.2)
Medicaid	77,509 (9.4)	11,519 (5.9)
Self-Pay	47,763 (5.8)	7,635 (3.9)
Other	16,049 (2.0)	1,700 (0.9)
Surgical, n (%)	377,109 (45.8)	60,314 (30.8)
Number of Elixhauser comorbidities, n (%)		
0	90,867 (11.0)	8,120 (4.2)
1–3	490,181 (59.5)	90,260 (46.1)
4	242,954 (29.5)	97,497 (49.8)
Risk of mortality on index hospitalization*, n (%)		
Minor	289,853 (35.2)	8,065 (4.1)
Moderate	226,598 (27.5)	22,062 (11.3)
Major	185,129 (22.5)	51,535 (26.3)
Extreme	122,421 (14.9)	114,185 (58.3)
Mechanical ventilation during index hospitalization, n (%)		
None	715,213 (86.8)	107,338 (54.8)
Without tracheostomy	94,097 (11.4)	77,332 (39.5)
With tracheostomy	14,692 (1.8)	11,177 (5.7)
Dialysis during index hospitalization, n (%)		
None	798,964 (97.0)	179,199 (91.5)
Dialysis (No ESRD on admission)	7,805 (1.0)	8,543 (4.4)
Dialysis (ESRD on admission)	17,223 (2.1)	8,105 (4.1)
Median length of index hospital stay, (IQR)	6 (3–10)	8 (4–17)
Discharge destination after index stay, n (%)		
Home	424,412 (51.5)	20,431 (10.4)
Home with health services	157,310 (19.1)	15,379 (7.9)
Skilled nursing facility	122,708 (14.9)	33,806 (17.3)
Long-term acute care hospital	1,481 (0.2)	680 (0.4)
Inpatient rehabilitation facility	40,703 (4.9)	3,665 (1.9)

	Died Within 6 Months of Admission	
	No (n=842,002)	Yes (n=195,847)
Hospice	3,212 (0.4)	11,222 (5.7)
Other *	73,175 (8.9)	9,168 (4.7)
Died during hospitalization	0 (0.0)	101,499 (51.8)

* "Other" discharge destination is comprised of patients with the following discharge locations: transfer to another hospital not within the SPARCS database, intermediate care facilities, assisted living facilities, leaving against medical advice, discharge to court/law enforcement, psychiatric hospitals and other type of health care institution not defined elsewhere.

Table 2

Ability of Existing Triggers to Predict 6-Month Mortality

Trigger	n	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	95% Confidence Interval
Any trigger	127,808	32.09	92.12	49.17	85.09	0.62	0.62–0.62
Age > 80 with two or more life-threatening comorbidities	26,977	6.69	98.32	48.54	81.59	0.53	0.52–0.53
Active stage IV malignancy	38,570	11.12	97.96	56.45	82.26	0.55	0.54–0.55
Post cardiac arrest	38,570	9.78	96.54	40.19	81.82	0.53	0.53–0.53
Intracerebral hemorrhage requiring mechanical ventilation	9,674	2.98	99.53	60.27	81.19	0.51	0.51–0.51
Global cerebral ischemia	15,574	5.94	99.52	74.75	81.66	0.53	0.53–0.53
Multi-system organ failure	1,289	1.06	99.93	77.68	80.95	0.50	0.50–0.51
Advanced stage dementia	2,666	0.27	99.91	40.73	80.82	0.50	0.50–0.50

PPV, positive predictive value; NPV, negative predictive value; AUC, area under the receiver operating characteristics curve.

Table 3

Subgroups with High-Risk of 6-Month Mortality, Identifiable on ICU Admission

	Age					
	60 to 69 years		70 to 79 years		80 years	
	n	Predicted Probability (%) (95% CI)	n	Predicted Probability (%) (95% CI)	n	Predicted Probability (%) (95% CI)
Sepsis	19,581	41.5 (41.3 – 41.8)	23,428	49.7 (49.5 – 50.0)	29,259	63.3 (63.1 – 63.5)
Metastatic Cancer	11,043	51.9 (51.5 – 52.3)	10,449	60.3 (59.9 – 60.6)	7,242	72.2 (71.8 – 72.5)
Solid Tumor without Metastases	11,460	45.4 (44.9 – 45.8)	12,246	51.5 (51.1 – 51.9)	10,016	62.2 (61.9 – 62.6)
Weight Loss	9,843	38.3 (37.9 – 38.8)	11,440	45.2 (44.8 – 45.6)	16,739	55.9 (55.6 – 56.2)