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FINAL Progress Report for 1R03HS023656-01A1

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Project Title: Pneumonia Mortality Risk Index to Support Discussions of Care Options with Elders
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FINAL Report Components:

1) STRUCTURED ABSTRACT:

Purpose- To use electronic medical record (EMR) data to develop a 30-day mortality assessment instrument among patients age > 75 years with the goal of integrating palliative care early in the hospital course for patients at high risk for mortality.

Scope- Data were abstracted for 1237 consecutive patients hospitalized from July 2011 to December 2014 from four hospitals in a Western New York hospital system. Participants were eligible if they were > 75 years of age and admitted to the ICU with pneumonia.

Methods- Data abstracted from the EMR included demographics, laboratory data, clinical data, and 30-day mortality. Logistical regression identified predictors of mortality. Area under the receiver operating curve (ROC) was calculated to quantify degree to which the model accurately classified participants. Using the coordinates of the ROC, a predicted probability was identified to indicate high versus low risk.
Results- In total, 1237 patients were included, with mortality data available for 100% of patients. The mortality rate equaled 14.3%. Age > 85 years; having active cancer, CHF, COPD, or sepsis; and being on a vasopressor medication were predictive of mortality. Using the derived index, with a predicted probability of > .146 as a cutoff, sensitivity equaled 70.6% and specificity equaled 65.6%. The area under the ROC was .735. This risk tool can help patients, families, and care teams make informed care decisions by identifying a patient group for whom careful review of goals of care is indicated both during and after hospitalization.

Key Words- community-acquired pneumonia, palliative care, older adult, risk assessment

2) PURPOSE (Objectives of the study)

The objective was to derive a risk index from EMR data available at the time of admission. We conducted a retrospective analysis of data readily available from the electronic medical record (EMR) for consecutive hospital admissions for older persons with pneumonia who initially presented to a hospital emergency department. Our goal was to develop an easily deployed risk index that required little practice change for busy and potentially overwhelmed emergency medicine providers but also could be integrated into a screening tool to prompt a palliative care evaluation early in the management of pneumonia and provide disease-specific outcome information for discussion with patients and surrogates.

3) SCOPE (Background, Context, Settings, Participants, Incidence, Prevalence)

Palliative care is often thought to be synonymous with end-of-life care, but the value of palliative care extends beyond this to include patients and family members coping with serious illness in the context of advanced chronic disease or frailty associated with aging. Palliative care is also an excellent example of patient centered care. The practice of each should avoid unnecessary, nonbeneficial interventions, requires careful consideration of the benefit to the patient for a diagnostic test or intervention, and relies upon interpersonal skills to assist patients and their families as they cope with serious illness. It has been proposed that the consistent provision of palliative care for this group of patients may improve patient outcomes, including the perceived quality as well as cost of care.

Pneumonia is a common cause of hospitalization, a common reason for admission to the medical intensive care unit (ICU), and a leading cause of death among older persons; a majority of pneumonia deaths occur in hospitals. Death in a hospital has been associated with unrelieved symptoms and unmet needs for physician communication and emotional support, deficits perhaps more prevalent in the technology-heavy intensive care unit. Dying in an ICU has also been associated with reduced perceptions of care quality, including inadequate shared decision making, inadequate emotional support for the decedent, too little information, and overall reduced quality of care. Transfer within 3 days of death and late transfer to hospice have been defined as markers for poor quality of care. Between 2000 and 2009, the use of intensive care units within 30 days prior to death increased for the Medicare population, as did the proportion of deaths occurring within 3 days of transfer to hospice.

Shared and informed decision making about care is fundamental to any process designed to reduce the rate of terminal ICU stays for persons with advanced age, frailty, and/or multiple comorbidities for whom the risks of a terminal ICU stay, when given the choice, may not be an acceptable part of the treatment plan for serious illness. Scientific evidence is an essential element to this decision-making process and can help patients and families understand the basis for clinical judgment and recommendations. Disease-specific data can help surrogates arrive at a more complete understanding of the patient's goals and preferences.

For persons presenting to the hospital with pneumonia, and at high risk for mortality, early palliative care intervention may improve outcomes for them as well as their family, particularly if the adverse outcomes associated with death in the ICU are avoided. Early access to palliative care has significantly improved quality of life for persons diagnosed with non-small-cell lung cancer. Integration of palliative care early in the hospital management of acute illness, even beginning in the emergency department, has also been proposed as a means to improve patient care; however, data supporting this are sparse. A lack of consensus among physicians and nurses and insufficient identification of patient's palliative care needs are barriers to early integration of palliative care into hospital management. Data and tools that help to consistently identify patients with palliative care needs can be used to address these barriers.

There are numerous risk indices available to assist physicians in predicting mortality from community-acquired pneumonia, including the Pneumonia Severity Index (PSI), CURB-65, and CRB-65. The sensitivity, specificity, and area under the receiver operating curve are similar for these common bedside risk assessment tools. These indices can be cumbersome to use and, because they are heavily weighted by age, are not particularly useful for discerning risk among persons age 75 years and older, those with the highest mortality risk. The indices work best when used to identify low-risk patients who can be safety treated as outpatients. Recent indices derived from the electronic medical record predict mortality from pneumonia about as well as the bedside tools but are proprietary, a major barrier to routine use and widespread adoption.

4. METHODS (Study Design, Data Sources/Collection, Interventions, Measures, Limitations)

The study is a retrospective chart review for patients age 75 and older admitted for pneumonia from 2011 to 2014 to four hospitals within one of the largest hospital systems in western New York. Retrospective data were abstracted from the electronic billing system to identify patients meeting inclusion criteria. The case-finding step resulted in a registry of patients (a consecutive sample of 1237 patients) age 75 years or older with an emergency department admission with pneumonia and hospital discharge (or in-hospital death) diagnosis of pneumonia. The hospital electronic medical record (EMR) and the Death Master File from the Social Security Administration were used to extract the remaining data (laboratory and clinical values, 30-day mortality status, and contextual data).

For this derivation and validation study, retrospective EMR data were abstracted for patients age > 75 years presenting to the emergency department with a diagnosis of pneumonia upon admission and at discharge. Electronic medical record data were obtained for 1237 consecutive patients hospitalized from July 2011 to December 2014 at four hospitals from one the largest hospital systems in western New York. Variables were selected based on findings from published studies and previous work and included age, gender, insurance type, comorbidities (chronic heart failure, chronic obstructive pulmonary disease, cancer, hypertension), laboratory data (albumin, blood urea nitrogen), clinical data (respiratory rate, persistent hypotension, use of vasopressor medications, diagnosis of sepsis, intubation status, length of stay), and 30-day mortality, determined using the Death Master File from the Social Security Administration.

To identify factors predictive of 30-day mortality, a binary logistic regression model was generated. Based on results of bivariate analysis, several factors were entered into the regression model as potential predictors. They were age > 85, having septicemia (0, 1), chronic obstructive pulmonary disease (0, 1), hypertension (0, 1), or active cancer (0, 1) as well as pressor use (0, 1), a BUN > 45 mg/dL (0, 1), and a respiratory rate > 30 breaths/minute (0, 1). An alpha level < 0.05 was considered significant for all statistical tests. Risk index derivation was performed by calculating the area under the receiver operating curve (ROC).

There are limitations, of course. This is a retrospective study and reflects outcomes for a limited number of patients treated in one city. The index was limited to the data available in the electronic medical record. Functional status prior to the acute illness and cognitive status prior to the acute illness and at presentation can be important prognostic factors following an acute illness, but those variables were very inconsistently recorded. Absence of these variables from the index likely limits its predictive value; however, consistently obtaining this information requires substantial practice change. The index represents a case-finding tool that should be followed up with a bedside assessment that would be expected to increase its predictive value. Use of this index is being externally validated, and the scoring may become more specific with a larger sample size.

5) RESULTS (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications)

Demographic characteristics and the results of the univariate analysis were examined. Overall, the group had a mean age of 83.8 (±5.7) years, and women represented 55.7% of the sample. Mortality data were available on all 1237 patients, and the overall mortality rate was 14.3%.

Prediction Model Developed Based on the Full Sample

Predictor	B	SE	Odds Ratio	Lower	Upper
Age > 85	0.452	.177	1.572	1.110	2.226
Cancer	1.344	.239	3.833	2.400	6.122
CHF	0.328	.176	1.388	0.984	1.960
COPD	-1.129	.272	0.323	0.190	0.551
Sepsis	1.454	.180	4.282	3.011	6.089
Pressors	1.221	.408	3.390	1.525	7.535
Constant	-3.049	.209			

The preliminary model revealed that age > 85; having active cancer, CHF, COPD, or sepsis; and being on vasopressor medication were predictive of 30-day mortality. Hosmer and Lemeshow's test suggested good model fit $X^2(7) = 4.35$, $p = .738$. The Brier score for the model was 0.11, indicative of adequate overall prediction accuracy; the calibration slope of 1.00 suggested that the model was well calibrated. The area under the ROC curve was .735 (95CI = .696, .775). Using a predicted probability of mortality greater than or equal to .146 as a cutoff score yields a sensitivity of 70.6% and a specificity of 65.6%.

Internal Validation Results

Performance Measure	Mean	Minimum	Maximum	SD
Brier score	.112	0.093	0.134	.008
Calibration slope	.950	0.629	1.408	.201
AUC	.724	0.679	0.785	.028
Sensitivity[1]	.672	0.556	0.803	.066
Specificity[1]	.666	0.628	0.708	.023

Note: 1. Sensitivity and specificity based on predicted probability greater than or equal to .146

The estimated predictive performance of the model based on the 30 repetitions from the internal validation process is very similar to the apparent performance reported for the model developed on the entire sample. The average Brier and AUC from the validation process are nearly identical. The average calibration slope of .95 suggests that the degree of overfitting is relatively minor. The estimated sensitivity from the validation process (67.2%) suggests that the 70.6% sensitivity at a predicted probability of .146 from the model development phase is optimistic.

This study utilized information readily available from an electronic medical record to construct a pneumonia risk index. The risk index was conceived as a tool to facilitate early identification of hospitalized older patients for whom a discussion and review of goals of care and careful consideration of treatment options could alter the plan of care during an acute hospital stay. Because the data were readily available from the EMR, we obtained a complete data set for a high proportion (89.1%) of patient records without a change in practice. The instrument could be incorporated into a checklist and EMR, used to inform discussions about preferences and processes of care without significant change in practice.

In general, there is a lack of specific data about outcomes of care for persons over age 75 years. The risk index that we derived is more specific to older persons than other pneumonia indices are. Both indices include age in the calculations, but neither addresses outcomes specifically for a group of persons age 75 years and older. The persons in the high-risk category for the PSI have a 27% risk of 30-day mortality, and those in the highest-risk category of the CRB-65 have a 30-day mortality risk of 31%. In our index, the highest risk group (those patients with all predictive factors in the model) has an estimated risk of mortality equal to 65%. Our preliminary data suggest that other indices may be significantly underestimating mortality for many older adults. Furthermore, each of the established indices has limitations to widespread adoption and use. The Pneumonia Severity Index, an important tool, requires collection of 20 data points, a fact that has limited its use in routine practice. The CRB-65 is much simpler to use but requires consistent assessment of mental status. We did not include mental status in our risk index, because it was very inconsistently recorded in the EHR. The 70% sensitivity of our model demonstrates better performance of our model compared with the PSI, at 63.6% sensitivity.

Reliance on the electronic medical record allows early review and identification of an at-risk group without requiring significant change in practice or a change in data gathering practices. If early intervention is a goal, then the index provides a simple way to identify patients at the time of admission following evaluation in the ED. Simple steps in individual practices are more likely to be adopted. The processes of care can be monitored from the EMR, reducing cost and effort needed for monitoring while retaining the ability to provide comprehensive care to patients at high risk of mortality during and after their acute hospital stay.

6 LIST OF PUBLICATIONS and PRODUCTS (Bibliography of Outputs from the study).

Satchidanand N, Servoss T, Singh R, Horton L, Naughton BJ. Development of a Mortality Index for Elders Admitted to the ICU with Pneumonia. *Journal of American Geriatrics Society.* 2017; In Review

Satchidanand N, Servoss T, Singh R, Horton L, Naughton BJ. Validation of an EMR-based Decision Tool to Support Early Discussions of Palliative Care among Elders in the ICU with Pneumonia. *Journal of American Geriatrics Society.* 2017; In preparation.

Meeting at which results were presented:

Preliminary model development was presented at the Center to Advance Palliative Care: National Seminar Poster Session, 2013.

Results were presented at Translational Science, April 13 – 15, 2016, in Washington, DC.