Comparison of a Frailty Risk Score and Comorbidity Indices for Hospital Readmission Using Electronic Health Record Data

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ABSTRACT

The purpose of the current study was to investigate the predictive properties of five definitions of a frailty risk score (FRS) and three comorbidity indices using data from electronic health records (EHRs) of hospitalized adults aged ≥50 years for 3-day, 7-day, and 30-day readmission, and to identify an optimal model for a FRS and comorbidity combination. Retrospective analysis of the EHR dataset was performed, and multivariable logistic regression and area under the curve (AUC) were used to examine readmission for frailty and comorbidity. The sample (N = 55,778) was mostly female (53%), non-Hispanic White (73%), married (53%), and on Medicare (55%). Mean FRSs ranged from 1.3 (SD = 1.5) to 4.3 (SD = 2.1). FRS and comorbidity were independently associated with readmission. Predictive accuracy for FRS and comorbidity combinations ranged from AUC of 0.75 to 0.77 (30-day readmission) to 0.84 to 0.85 (3-day readmission). FRS and comorbidity combinations performed similarly well, whereas comorbidity was always independently associated with readmission. FRS measures were more associated with 30-day readmission than 7-day and 3-day readmission. [*Research in Gerontological Nursing, 14*(2), 91-103.]

Unplanned hospital readmissions are frequent, costly, and exert considerable disruption and distress in the lives of patients and their families and caregivers. The recent focus on readmissions in the United States and Europe is motivated by their negative effects on costs and underlies global concern for patient safety and quality of care. *Hospital readmission*, defined as an admission to a hospital within 30 days of a discharge from the same or another hospital, affects 17.1% of Medicare beneficiaries, and 13.9% of all payers for 2016, costing the health care system $17.6 billion annually (Bailey et al., 2019; Centers for Medicare & Medicaid Services [CMS], 2019). Cost estimates for un-

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planned hospital readmission average $14,400 for each all-cause readmission (Bailey et al., 2019). The Medicare Payment Advisory Commission estimates that 12% of these hospital readmissions are potentially avoidable. To address burgeoning health care costs and patient safety, the Hospital Readmissions Reduction Program authorized the CMS (2019) to levy financial penalties by reducing payments to hospitals with excessive readmissions for several quality indicator conditions, such as acute myocardial infarction, heart failure, and pneumonia. Reducing hospital readmission has drawn attention to potential organizational and patient-related issues that contribute to preventable readmissions in efforts to improve inpatient care quality and transitions in care from hospital to home.

A singular etiology of hospital readmissions is difficult to pinpoint. Health system or provider-related factors, such as provider practice patterns, staffing, medical errors, and suboptimal patient care, are often implicated as triggers of early readmission, whereas patient-related factors, including multimorbidity, chronic disease exacerbation, health behaviors, and adverse medication effects, have been implicated in hospital readmission (Aubert et al., 2019). Patient-related factors, such as frailty and comorbidity, may also signal high risk. Hospitalized, acutely ill older adults often experience higher levels of frailty and comorbidity that adversely impact their responsiveness to treatment and recovery and contribute to readmission risk.

Frailty is a clinical syndrome resulting from physiological impairments and failed integrative responses across multiple systems with diminished capacity to resist and recover from stressors (Rodríguez-Mañas & Sinclair, 2014; Zaslavsky et al., 2012). The concept of frailty provides a framework to understand the vulnerability that renders individuals more susceptible to negative consequences, such as functional decline, dependence, disability, new morbidity, falls, hospital readmission, discharge to an institution, and in-hospital mortality (Cunha et al., 2019). In the acute care setting, the prevalence of frailty ranges from 25% to 97% depending on the frailty tool used (Cunha et al., 2019). Given its high prevalence and negative impact, frailty is considered an important concept for clinical care (Kim, 2020; World Health Organization [WHO], 2015; Zaslavsky et al., 2012).

Despite a plethora of frailty assessment tools that exist for screening and diagnosis, many tools require subjective (surveys) and/or objective (direct measurement) instruments, which hinder adoption due to lack of geriatric expertise, time, and equipment to conduct these assessments. Several systematic reviews highlight the uneven quality and variable predictive accuracy of frailty instruments that are applied in the acute care setting (Lim et al., 2019; Theou et al., 2018). A scoping review on frailty assessment in the acute care setting found that of the 20 studies ($N = 617$) that applied a frailty tool in risk models for rehospitalization, only 10 tools were predictive (Theou et al., 2018). Similarly, another systematic review that examined 16 frailty tools for screening older adult inpatients concluded that no tool demonstrated strong validity, reliability, or feasibility, and only two studies reported discrimination for 30-day readmission (area under the curve [AUC] range = 0.55 to 0.72) (Warnier, van Rossum, van Velthuijsen et al., 2016). There is growing interest in using electronic health record (EHR) data and International Classification of Diseases (ICD) codes in readmission risk prediction models due to their availability and access to numerous diverse data points and large datasets without imposing additional burden on patients or clinicians; however, there are various approaches for how frailty is defined and measured (Kim, 2020; Zaslavsky et al., 2012).

Comorbidity, a term to describe the coexistence of two or more medically diagnosed diseases in a patient, is common in older adults (Zhao & Yoo, 2017). Conceptually, a comorbidity index is more than a numeric count of the comorbidities that are present but unrelated to the principal problem for the hospital admission and represents the combined contributions of individual comorbidities to reflect burden of illness (Yurkovich et al., 2015). Comorbidity affects 50% to 99% of hospitalized patients (Aubert et al., 2019), and approximately one third of Medicare beneficiaries aged >65 years have four or more chronic conditions (Whitson et al., 2016). Comorbidity is one of the most common predictors used in risk models because it is well established that comorbidities are associated with more complex care and undesired health outcomes (Zhao & Yoo, 2017). Comorbidity indices, such as the Charlson Comorbidity Index (CCI) (Charlson et al., 1987) and the Elixhauser Comorbidity Index (ECI) (Elixhauser et al., 1998), have demonstrated valid prognostic indicators for mortality in various subgroups and clinical conditions of hospitalized adults, but evidence on their predictive performance for hospital readmission is limited and accuracy is modest (Quan et al., 2011). Recent systematic reviews examining risk prediction models for 30-day hospital readmission found inconsistent performance with a wide-ranging c-statistic (0.21 to 0.88), and none of the models that applied comorbidity measures were shown to be superior (Kansagara et al., 2011; Zhou et al., 2016).

In recent years, there has been increased interest in de-

veloping more effective risk prediction models for hospital readmission due to myriad demands on health care systems and higher costs. This growing body of literature is also motivated by interest in better targeting the delivery of enhanced care processes and transitional care interventions to patients at greatest risk to improve care quality and outcomes and reduce readmission (Jeffery et al., 2019). Considering the prevalence and negative impact of frailty on patient outcomes in the acute care setting and recognition that many patients who are frail also present with comorbidity (Vetrano et al., 2019), a better understanding of how frailty and comorbidity contribute to readmission risk would inform more effective risk prediction models to identify high-risk patients and accelerate development of targeted strategies to prevent readmission.

The aims of the current study were to (1) investigate the predictive properties of five definitions of a frailty risk score (FRS) consisting of ICD, 10th Revision, Clinical Modification (ICD-10-CM) classification codes and laboratory blood biomarkers and three comorbidity indices derived from the EHR of hospitalized adults aged ≥50 years and examined in models controlling for sociodemographic and clinical covariates for unplanned all-cause readmission at 3 days, 7 days, and 30 days; and (2) identify the optimal FRS and comorbidity index combination with highest discrimination for readmission outcomes.

METHOD

Study Design

The current study was an observational, cohort study and retrospective analysis of EHR (Epic®) data from a health system in the Southeastern United States. Electronic files of anonymized patient data were transferred into the university's high security virtual desktop followed by data preprocessing, cleaning, transformation, and analyses using a de-identified dataset.

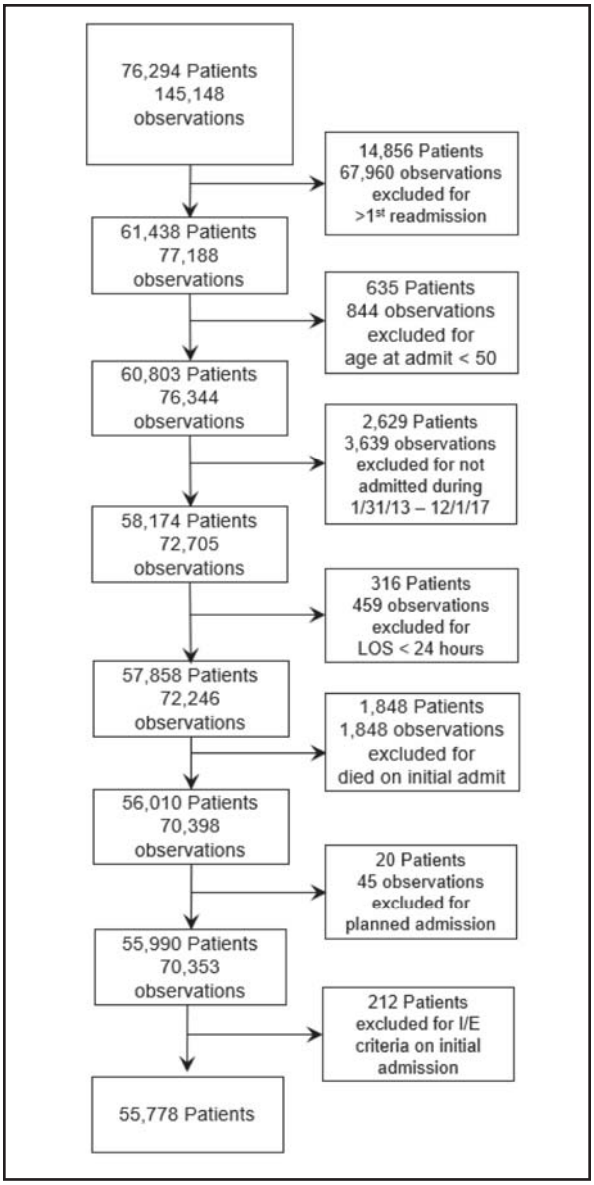

Figure 1. Study flowchart.
Note. LOS = length of stay; I/E = inclusion/exclusion.

Setting and Study Population

The health system encompasses five hospitals with a capacity that ranges from 83 to 535 beds; the largest hospital is a level-2 trauma center that provides multispecialty medical and surgical services. The other hospitals are two community hospitals serving medical and surgical specialties, one women's health hospital, and one behavioral health hospital. The sample included all hospital admissions for adults aged ≥50 years who had an inpatient stay of >24 hours and were hospitalized between 2013 and 2017 (N = 76,294). Patients were excluded if the index admission occurred before January 31, 2013 or after December 1, 2017. Age ≥50 years was selected based on evidence that frailty is consequential in middle-aged adults with prevalence ranging from 5.8% to 27.3% (Lafortune et al., 2016; Santos-Eggimann et al., 2009). Patients with a planned readmission within 30 days of hospital discharge or who died during hospitalization were excluded. Derivation of the final sample (N = 55,778) for analyses is displayed in the study flowchart in **Figure 1**.

Measures

Sociodemographic and Clinical Data. Sociodemographic and clinical data from the index admission included in

the analyses were: age, sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, other), marital status (married/partnered, separated/divorced, widowed, single, other), living arrangement (lives alone, lives with spouse/others, assisted living/group home, other), preadmission residence (home, assisted living/group home, nursing home, shelter/homeless, other), discharge disposition (home, home health, nursing home, hospice, rehabilitation hospital, other), primary insurance payer (Medicare, Medicaid, dual Medicare/Medicaid, self-pay/no charge, private insurance/other), emergent admission, time of discharge, has a primary care provider, regularly sees primary care provider, length of stay (LOS), polypharmacy (defined in the EHR as patient taking seven or more prescribed medications), principal problem (primary reason for hospital admission), and secondary medical diagnosis (conditions that are present but not directly associated with principal problem) based on ICD-10-CM codes.

Frailty. A FRS was originally investigated in a retrospective study of hospitalized older adults as a biopsychosocial construct comprising 16 geriatric syndromes, psychosocial risk factors, and blood biomarkers derived from nurse and physician documentation and laboratory data manually extracted from a different EHR dataset (Lekan et al., 2017). For this study, two of the original risk factors were divided into two constructs: malnutrition (malnutrition and abnormal weight) and social support (social support and material resources) for a total of 18 risk factors. Then, ICD-10-CM codes for patients' clinical diagnoses were mapped to the FRS risk factors (**Table 1** and **Table A** [available in the online version of this article]). Additional frailty risk factors that were available in the EHR dataset were also investigated for the FRS for a total of 26 potential frailty risk factors. Risk factors were scored dichotomously as 0 = *not present* and 1 = *present* and then (unweighted) summed, with higher scores indicating greater frailty (Lekan et al., 2017). Blood laboratory values were transformed into binary indicators based on reference range (**Table B**, available in the online version of this article).

Five FRSs were constructed to investigate various combinations of risk factors (18 to 26 risk factors) using the ICD-10-CM diagnosis codes from the problem list of conditions not associated with the principal problem (**Table 1**). Blood biomarkers were treated as a dichotomous variable based on the reference range for abnormal high or low (identified as "Labs" in the FRS) or as a proxy variable based on ICD-10-CM codes for the abnormal laboratory value (identified as "ICD" in the FRS definition). For example, the ICD-10-CM code for anemia was used as a proxy for abnormal low hemoglobin value (**Table A** and **Table B**). Analytic sample sizes were reduced for certain FRSs due to missing data for blood biomarkers.

Charlson Comorbidity Index (CCI). The CCI (Charlson et al., 1987) is a widely used comorbidity index that was originally developed for prediction of 1-year mortality in cancer patients and later validated in other patient populations and outcomes (Sharabiani et al., 2012; Yurkovich et al., 2015). The original CCI comprised 19 secondary medical conditions that were each assigned a weight. Higher scores indicate poorer health and greater mortality risk. The CCI was computed for the ICD-10-CM codes according to Quan et al. (2005) (referred to as CCI-17). We also used the updated CCI by Quan et al. (2011) (referred to as CCI-12) that included risk adjusted weights for 12 comorbidities.

Elixhauser Comorbidity Index (ECI). Elixhauser et al. (1998) developed a comprehensive index comprising 30 comorbidities representing secondary diagnoses that were present on admission and not related to the principal diagnosis. The ECI was computed for 30 unweighted comorbidities using the ICD-10-CM codes according to Quan et al. (2005). **Table C** (available in the online version of this article) provides the cross-matched list of comorbidities for the CCI-17, CCI-12, and ECI.

Outcomes

The primary outcome was time to first readmission defined as unplanned readmission following discharge from the initial index admission within the study period for 3-day, 7-day, and 30-day readmission.

Statistical Analysis

Descriptive statistics and data visualizations for the five FRS definitions, the three comorbidity indices (CCI-17, CCI-12, and ECI), and sociodemographic and clinical variables were assessed. Continuous variables were summarized as mean and standard deviation; categorical data were summarized as count (*n*) and percent (%). Data were examined for normality and outliers. Missing data were examined for their amounts and patterns; patients who were missing laboratory blood biomarkers for the FRS were excluded from analyses for that FRS model. Spearman correlations between each FRS and comorbidity index combination were examined. Multivariable logistic regression analyses were conducted to examine associations separately with 3-day, 7-day, and 30-day readmission, where adjusted odds ratios (AORs) were estimated to quantify effects of independent variables (along with their 95% confidence intervals [CIs]). Modeling was run for each com-

TABLE 1

Frailty Risk Score (FRS) Definitions

Frailty Risk Factors	Frailty Risk Score (FRS)				
	FRS-18-Labs[a] ($n = 30,791$)	FRS-21-Labs ($n = 30,753$)	FRS-25-Labs ($n = 30,753$)	FRS-19-ICD ($n = 55,095$)	FRS-26-ICD ($n = 55,095$)
1 Malnutrition	X	X	X	X	X
2 Abnormal weight	X	X	X	X	X
3 Weakness	X	X	X	X	X
4 Fatigue	X	X	X	X	X
5 Dyspnea	X	X	X	X	X
6 Chronic pain	X	X	X	X	X
7 Smoking	X	X	X	X	X
8 Vision problems	X	X	X	X	X
9 Urine incontinence	X	X	X	X	X
10 Falls	X	X	X	X	X
11 Delirium	X	X	X	X	X
12 Depression	X	X	X	X	X
13 Dementia	X	X	X	X	X
14 Social support	X	X	X	X	X
15 Material resources	X	X	X	X	X
Additional risk factors					
16 Dysphagia			X	X	X
17 Difficulty walking			X	X	X
18 Fecal incontinence			X	X	X
19 Decubitus ulcer			X	X	X
Blood biomarkers[b]					
20 Albumin, low	X	X	X		X
21 Creatinine, high		X	X		X
22 Glucose, abnormal		X	X		X
23 Hemoglobin, low	X	X	X		X
24 Sodium, high or low		X	X		X
25 WBC, high or low	X	X	X		X
26 CRP, high[c]				X	

Note. ICD = International Classification of Diseases; WBC = white blood cells; CRP = c-reactive protein.
[a] Original FRS consisted of 14 risk factors and four blood biomarkers (albumin, CRP, hemoglobin, and WBC) that were analyzed as abnormal high or low according to institutional laboratory reference ranges.
[b] Blood biomarkers were operationalized as an ICD-10-CM diagnosis code (indicated in FRS definition as "ICD") or as the laboratory reference range for blood specimens, analyzed as abnormal high or low according to institutional parameters (indicated in FRS definition as "Labs").
[c] CRP blood specimen prevalence in the study sample was insufficient (<2%) for analyses.

bination of FRS and comorbidity index, adjusting for sociodemographic and clinical characteristics as previously described, and specific comorbidity index and FRS combination. AUC of receiver operating characteristic curves were used to quantify accuracy. Analyses were conducted using SAS version 9.4. A two-sided p value < 0.05 was considered statistically significant and is reported along with effect size (AOR) and its precision (95% CI) (Wasserstein & Lazar, 2016).

Ethical Considerations

The study was conducted in accordance with the uni-

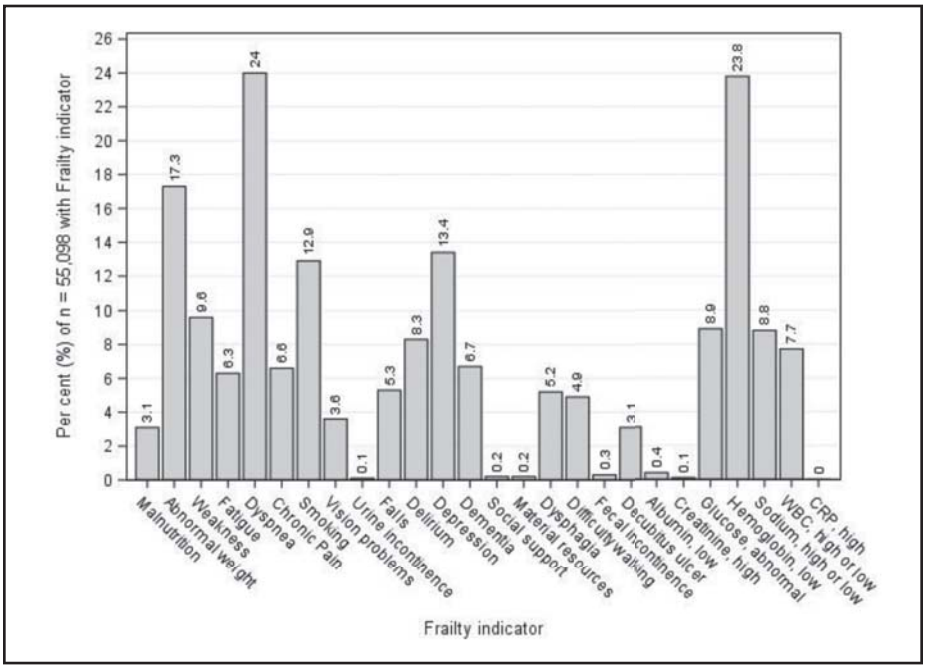

Figure 2. Prevalence of frailty risk factors (patient population, $N = 55,098$).

TABLE 2

Spearman Correlations Among Frailty and Comorbidity Measures

	1	2	3	4	5	6	7	8
1. CCI-17	1.000							
2. CCI-12	0.841	1.000						
3. ECI	0.701	0.620	1.000					
4. FRS-18-labs	0.303	0.341	0.473	1.000				
5. FRS-21-labs	0.329	0.351	0.473	0.913	1.000			
6. FRS-25-labs	0.339	0.358	0.482	0.904	0.983	1.000		
7. FRS-19-ICD	0.342	0.341	0.569	0.765	0.662	0.710	1.000	
8. FRS-26-ICD	0.367	0.367	0.615	0.749	0.682	0.722	0.901	1.000

Note. CCI = Charlson Comorbidity Index; ECI = Elixhauser Comorbidity Index; FRS = Frailty Risk Score; ICD = International Classification of Diseases. Sample size ranged from $N = 54,396$ to 55,098 for all variables not including FRS-18-Labs, FRS-21-Labs, or FRS-25-Labs. Otherwise, $n = 30,672$ to 30,791. All $p < 0.0001$.

versity and health system data use agreements and institutional review board approval for a limited dataset with a waiver of research consent and HIPAA authorization.

RESULTS

A total of 55,778 patients remained after study inclusion/exclusion criteria were applied (**Figure 1**). Mean patient age was 68.9 years (*SD* = 11.3 years), 20% were aged ≥80 years, 53% were female, 73% were non-Hispanic White, 53% were married, 21% lived alone, 55% were on Medicare, and for 12% the primary or secondary insurance payer was Medicaid (**Table D**, available in the online version of this article). Most patients were admitted from home (89%), 59% were emergent admissions, and median LOS was 3.2 days (mean = 4.3 days, *SD* = 3.8 days, range = 1 to 103.6 days). The top reasons for admission included osteoarthritis of the knee, chest pain, cerebral infarction, pneumonia, sepsis, and syncope. Patients who were readmitted within 30 days were descriptively different according to emergent admission, primary reason for admission, preadmission residence, insurance payer (i.e., Medicaid, Medicare, dual), LOS, polypharmacy, discharge timing, discharge disposition to rehabilitation hospital, comorbidity (CCI-12, CCI-17, or ECI), and frailty as measured by the FRS compared to patients who were not readmitted within 30 days.

Frailty and Comorbidity

Figure 2 displays the prevalence of the 26 individual FRS risk factors based on ICD-10-CM coding for the five different FRSs. The top five risk factors were dysphagia, dementia, abnormal weight, depression, and smoking, with prevalence ranging from 12.9% to 24%; the prevalence of the seven blood biomarkers was highest for albumin, glucose, hemoglobin, and white blood cell (WBC) count (range = 27% to 79.5%). The mean FRS for the five definitions ranged from 1.3 (*SD* =

1.5) to 4.3 (*SD* = 2.1), where the average FRS was higher among patients who were readmitted within 30 days compared to patients who were not readmitted. The mean comorbidity scores for the CCI-12, CCI-17, and ECI were also higher among patients who were readmitted within 30 days compared to those who were not readmitted. The FRSs and comorbidity indices were positively correlated (**Table 2**) (FRS-18-labs and CCI-12 [$r_s = 0.303$, $p < 0.001$]; FRS-26-ICD and ECI [$r_s = 0.615$, $p < 0.001$]). Given this finding and the remaining r_s values < 0.60 together suggests that frailty and comorbidity were empirically distinct within our study.

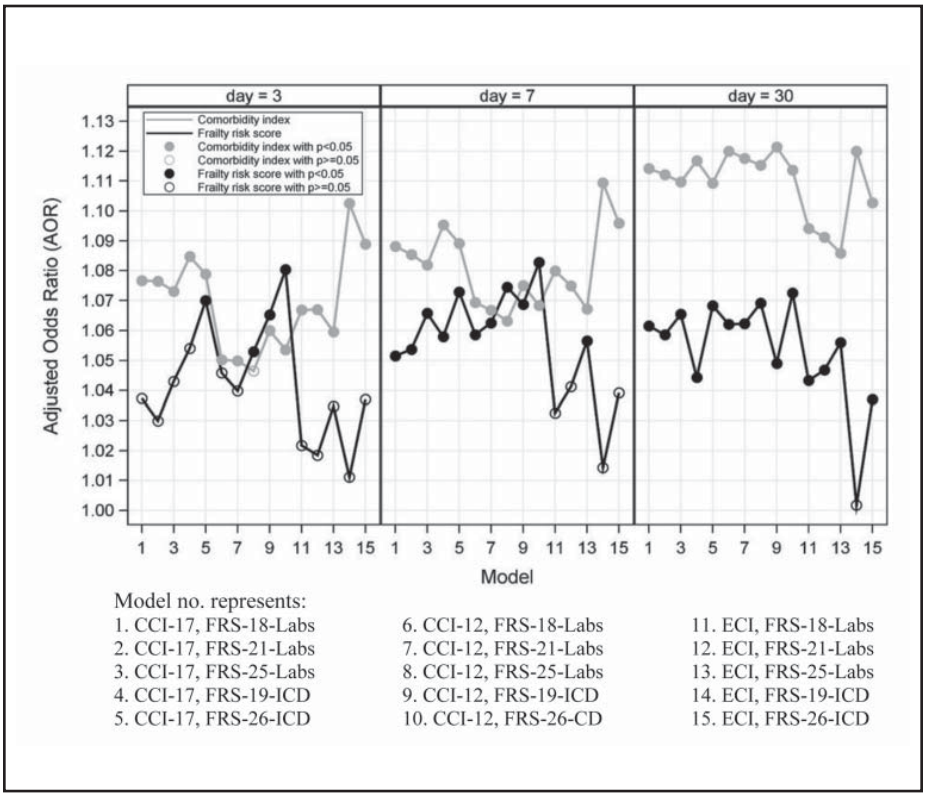

Figure 3. Adjusted odds ratios for Frailty Risk Score (FRS) and comorbidity combination from multivariable logistic regression modeling of 3-day, 7-day, and 30-day first readmission.
Note. CCI = Charlson Comorbidity Index; ECI = Elixhauser Comorbidity Index; ICD = International Classification of Diseases. Adjusted for: age at admission (years), gender, race/ethnicity, lives alone status, length of stay first hospitalization (days), emergent admission, has a primary care provider (PCP), sees PCP regularly, polypharmacy (takes 7+ prescribed medications), top 10 primary index admission problem, discharge disposition first hospitalization, hospital, year of admission, marital status, insurance payer, pre-admission residence, and specific comorbidity index (CCI-17, CCI-12, ECI) and FRS combination.

Frailty, Comorbidity, and Readmission Outcomes

There were 15 models for the 15 combinations of frailty and comorbidity indices for each readmission outcome (3-day, 7-day, 30-day). The AORs, illustrated in **Figure 3**, ranged from 1.05 to 1.10 (shown with grey line) for comorbidity for 3-day readmission depending on the comorbidity index applied. AORs ranged from 1.01 to 1.08 (shown with black line) for FRSs, with only four of 15 models having significant adjusted frailty effects (indicated by solid bullets). For 7-day readmission, 11 of 15 models had significant independent effects of FRSs (AOR range = 1.01 to 1.08), whereas comorbidity index was always significant (AOR range = 1.06 to 1.11). For 30-day readmission, the FRS was independently associated with readmission for 14 of 15 models (AOR range = 1.00 to 1.07), whereas comorbidity effects (all with $p < 0.05$) ranged in size of AORs of 1.09 to 1.12. Predictive accuracy was high for all models, with AUC ranging from 0.84 to 0.85 for 3-day readmission, 0.80 to 0.81 for 7-day readmission, and 0.75 to 0.77 for 30-day readmission (**Figure 4** and **Table D**).

Optimal Model for Readmission Outcomes

In this study of >55,000 hospitalized adults age ≥50 years in our health system, we found that although the five FRS and three comorbidity models performed similarly well for all readmission outcomes (in 15 models), the best models based on AUC were the FRS-26-ICD/ECI combination for 3-day and 7-day readmission and the FRS-26-ICD/CCI-12 combination for 30-day readmission. The FRS-26-ICD, which consisted entirely of ICD-10 codes, including proxy codes for blood biomarkers, showed slightly greater performance compared to the FRS models that included blood biomarkers.

DISCUSSION

Best practices for reducing hospital readmission include identifying high-risk patients, comprehensively assessing modifiable risk factors, and targeting these risks in care pathways and transitional care programs to prevent readmissions (Burke et al., 2016). Progress has been hin-

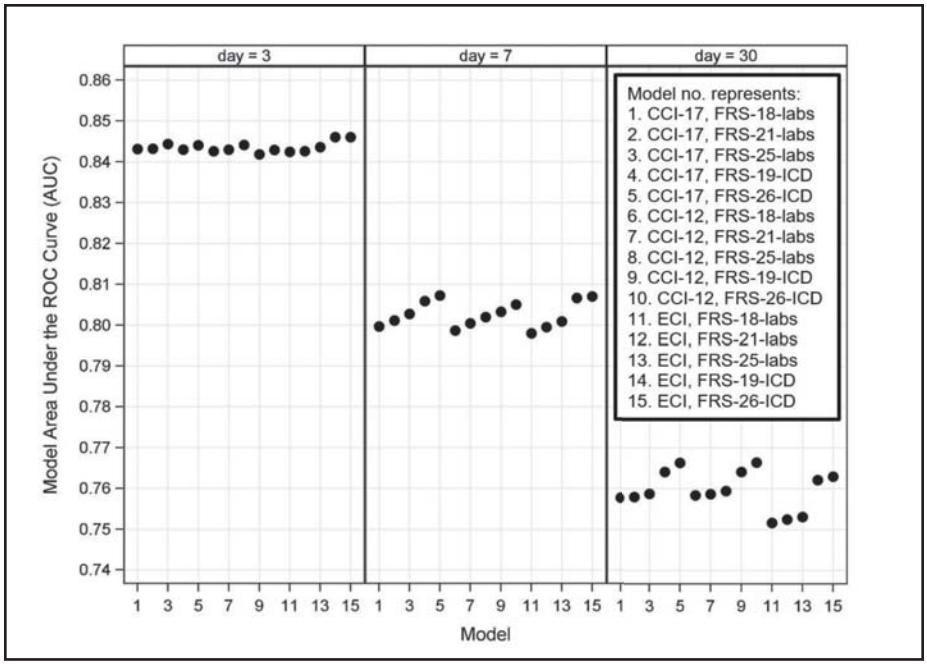

Figure 4. Accuracy of modeling readmission by frailty and comorbidity combination. Note. FRS = Frailty Risk Score; CCI = Charlson Comorbidity Index; ECI = Elixhauser Comorbidity Index; ICD = International Classification of Diseases. Adjusted for: age at admission (years), gender, race/ethnicity, lives alone status, length of stay first hospitalization (days), emergent admission, has a primary care provider (PCP), sees PCP regularly, polypharmacy (takes 7+ prescribed medications), top 10 admission reasons/primary admission problem, discharge disposition first hospitalization, hospital, year of admission, marital status, insurance payer, pre-admission residence, and specific comorbidity index (CCI-17, CCI-12, ECI) and FRS combination.

dered in meeting readmission reduction goals by lack of risk prediction tools with acceptable performance metrics that could identify high-risk patients and potentially preventable readmissions. Our results demonstrate that models that include frailty as measured by a FRS and comorbidity index (CCI-17, CCI-12, or ECI) reasonably predict hospital readmissions at 3 days, 7 days, and 30 days. To our knowledge, no previous studies have compared frailty definitions that included proxy measures for geriatric syndromes, psychosocial risk factors, and blood biomarkers, and three comorbidity indices using ICD-10-CM codes in risk prediction models for several readmission outcomes.

The current study extends prior investigation of the FRS that was originally derived from EHR nursing and physician documentation in which frailty was marginally associated with readmission in hospitalized adults aged ≥55 years (AOR = 1.18, p = 0.086, AUC = 0.66; N = 278) (Lekan et al., 2017). In further analyses, Lekan and McCoy (2018) examined inpatients with and without diabetes mellitus and found that frailty was significantly associated with increased odds of rehospitalization within 30 days of discharge (AOR = 1.24, p = 0.037). In the current study, we configured the FRS using ICD-10-CM codes to explore different FRS definitions using additional frailty risk factors available in the EHR. We found that differences in model discrimination were small for the 15 FRS/comorbidity combinations; however, the best performing model for 3-day and 7-day readmission was the FRS-26-ICD and ECI combination (AUC = 0.846 and 0.807, respectively) and for 30-day readmission, the FRS-26-ICD and CCI-12 combination (AUC = 0.766). Overall, the adjusted FRS and comorbidity combination models outperform other all-cause readmission prediction models that include frailty (Cunha et al., 2019; Lim et al., 2019; Warnier, van Rossum, van Velthuijsen, et al., 2016) or comorbidity (Kansagara et al., 2011; Yurkovich et al., 2015; Zhou et al., 2016) for hospital readmission outcomes. These models used proxy ICD-10-CM codes for the blood biomarkers, which suggests that the laboratory tests did not appreciably improve model performance.

Comorbidity indices are commonly used in risk prediction models; however, the optimal index to use for readmission outcomes has not been endorsed (Sharabiani et al., 2012; Zhou et al., 2016). Although there is only partial overlap in the group of comorbidities covered by the CCI and ECI, and many diseases are not included by either (**Table C**), we found that these indices performed similarly well for the readmission outcomes with good predictive accuracy despite some evidence that points to the superiority of the ECI in models for mortality (Sharabiani et al., 2012). Better model performance for the FRS and comorbidity combination in our analyses may be explained by the representation of disease burden (comorbidity) and syndrome/symptom burden (FRS). Comorbidity indices are not calibrated for disease severity; thus, the count of medical conditions has limited capacity to accurately char-

acterize the combined impact of comorbidities on health status and vulnerability. Further, the syndromes/symptoms in the FRS definition reflect the impact of disease as well as aging processes, lifestyle behaviors, and psychosocial factors. Poor to moderate performance of comorbidity indices in risk prediction models for acutely ill, medically complex, hospitalized patients suggests that all relevant factors that contribute to readmission risk are not represented, and the models that include the FRS, comorbidity, and covariates as applied in our analyses may provide a more comprehensive and holistic representation of the patient's health status and risk.

Our findings contrast with research that indicates poor to moderate discrimination in prediction models that include frailty and comorbidity. Although frailty and comorbidity may overlap, we found these constructs are empirically distinct and support using a FRS and CCI or ECI combination in readmission risk models. A recent investigation of models that included two frailty measures—the Sinai Abbreviated Geriatric Evaluation (SAGE) and the Fried frailty phenotype—CCI, and the American Society for Anesthesiology (ASA) Physical Status Class in surgical patients found that these measures demonstrated poor discrimination for readmission in adjusted models (SAGE and frailty phenotype, AUC = 0.66; CCI, AUC = 0.63; ASA, AUC = 0.63) (Katlic et al., 2019). In a study of adults aged ≥18 years who were admitted to inpatient medicine services, frailty (as measured by the Clinical Frailty Scale, which is scored based on provider judgment) and assessment of physical function from very fit to terminally ill had modest discrimination in models adjusted for age, sex, and LACE (Length of stay; Acuity of the admission; Comorbidities measured by the Charlson Comorbidity Index; Emergency department visits in the past 6 months) index for 30-day readmission (odds ratio = 1.42, 95% CI [0.81, 2.49]; AUC = 0.67) (Kahlon et al., 2015). Both investigations required clinical assessments, which imposes implementation burden in contrast to using existing EHR data to classify frailty using routinely collected data as described for the FRS in the current study. However, a Hospital Frailty Risk Score (HFRS) derived from ICD-10-CM codes in the EHR using cluster analysis in adjusted models with CCI in hospitalized older adults aged >75 years demonstrated poor discrimination for 30-day emergency department readmission (AUC = 0.61) (Gilbert et al., 2018). The HFRS included acuity-related conditions (e.g., infections, cerebrovascular disease) and syndromes (e.g., falls, delirium, dementia, incontinence) that were derived from 109 diagnosis codes that were at least twice as common in older inpatients aged ≥75 years, which may have skewed frailty risk toward high-resource use diagnosis codes for acute conditions and may or may not classify frailty (Shi & Kim, 2019).

The availability of health care databases has contributed to their use to quantify frailty in hospitalized older adults. Most often, the Fried frailty phenotype or Rockwood deficit accumulation frailty index are used as the reference standard to map frailty using administrative claims data or clinical EHR data (Kim, 2020; Theou et al., 2018). Soong et al. (2015) investigated several risk prediction models that included various combinations of a geriatric syndrome–based frailty assessment similar to the FRS, patient demographics, and comorbidity (CCI) using ICD-10-CM codes and found that their predictive accuracy for 30-day readmission was modest (range of AUC = 0.57 to 0.63); similarly, models that included only age, gender, and CCI demonstrated AUC of 0.59, suggesting improved precision when models include frailty. Several studies modeling frailty in Medicare databases indicate that frailty can predict some outcomes better than comorbidity at the population level but may have limitations in guiding individual care (Kim et al., 2020; Segal et al., 2017). Frailty measures developed from health care databases tend to rely on diagnoses, whereas clinical frailty assessments rely more on functional status (Kim et al., 2020). Frailty instruments define population subgroups by frailty level and offer an efficient approach (Kim et al., 2020). Using the ICD coding structure demonstrated in our study may facilitate identification of high-risk patients across medical specialties when clinical assessments are not feasible.

Several investigators have found that a frailty risk instrument based on geriatric syndromes similar to the FRS using clinical EHR data (versus ICD-10-CM diagnosis codes) was significantly associated with readmission (Borkenhagen et al., 2018; Kan et al., 2018). In contrast to comorbidity, a focus on frailty and geriatric syndromes that moves away from disease-based approaches toward a more holistic approach improves outcomes in older adults (Morley, 2017; WHO, 2015). A drawback of this approach is the need for additional clinical assessment and examination. Adoption of geriatric assessment in hospital practice is not widespread and even in settings that incorporate these assessments, some patient subgroups would be excluded due to lack of geriatric expertise, time to conduct assessments, and policies and procedures that embed these assessments in systems of care. Future research aimed toward achieving consensus on the ideal method to operationalize frailty in the acute care setting using EHR data,

including replication studies of the FRS, is needed to validate the relevance and contribution of frailty in risk prediction. These investigations will facilitate awareness about the relevance of frailty in quantifying risk in the hospital population and facilitate adoption of best practices for frailty assessment and efforts to reduce hospital readmissions.

The current study is novel in that we examined 3-day, 7-day, and 30-day readmission, as there is some dispute that the 30-day timeframe represents a homogenous period after discharge. In our study, more than one half of readmissions occurred within 7 days. Factors associated with earlier readmission may appreciably differ from those that occur later in the 30-day window. In one study of medicine inpatients, comorbidity, number of admissions in prior 12 months, and in-home medical services after discharge were associated with higher odds of readmission in both early (0 to 7 day) and later (8 to 30 day) readmission; however, early readmission was associated with LOS, social determinants of health, and discharge time (Graham et al., 2015). Similarly, we found that earlier readmission was associated with LOS and Medicaid payor (considered a proxy for social determinant of health), which may reflect greater medical complexity and care needs (Zhao & Yoo, 2017). The high 3-day readmission rate among patients from a rehabilitation hospital in the current study highlights potential system issues, such as timing and coordination of discharge, as well as patient factors, such as readiness, medical complications, and nonadherent behaviors to the treatment plan, as cited by Burke et al. (2016).

LIMITATIONS AND FUTURE DIRECTIONS

The current study has several strengths, including a large diverse inpatient sample from a health system and minimal missing data, which increases confidence in our findings. However, certain limitations should be considered. The accuracy and completeness of EHR documentation and the ICD-10-CM codes that were used to construct the FRS and comorbidity indices may not represent all of the relevant conditions experienced by patients. Undercoding of chronic conditions is a widespread problem that may affect the accuracy of the FRS/comorbidity model performance (Wright et al., 2015). Certain chronic conditions may be less likely recognized or coded by clinicians (urinary incontinence, dementia) compared to acute conditions (stroke) or more recognized chronic conditions (diabetes and hypertension) (Kim, 2020). Furthermore, coding tends to rely on medical diagnoses, whereas frailty is characterized by co-occurring syndromes, such as weakness, weight loss, delirium, incontinence, and falls. Codes that describe syndromes and symptoms may not be entered if the syndrome/symptom is routinely associated with the disease process for an already coded medical diagnosis (CMS, 2019). The FRS psychosocial risk factors are also likely to be under-coded (Kan et al., 2018). In addition, diagnosis coding fields are limited in number, restricting codes that more comprehensively characterize patient health status. A proportion of our sample did not have certain blood biomarkers; thus, we reduced sample size for two models, which may have affected model performance. The lower prevalence of laboratory tests is in keeping with cost containment trends, which have limited routine bloodwork. The FRS was constructed using ICD codes that were recorded based on admission comorbidities and medical problems that occurred during hospitalization; thus, its use for real-time clinical decision support during hospitalization may have limitations; frailty subtypes based on clusters of the individual FRS risk factors may guide patient screening, risk segmentation, and care planning. Finally, objective measures of frailty may be more sensitive than frailty defined by ICD-10-CM codes; thus, our FRS needs to be compared against a clinical frailty assessment (Kim, 2020; Warnier, van Rossum, van Leendert, et al., 2016).

Despite limitations, the current study adds to knowledge regarding the secondary use of EHR data and provides a novel approach to include frailty and comorbidity in readmission risk prediction models. Frailty assessment needs to be comprehensive and multidimensional as represented in the FRS to avoid missing aspects of health status and patient care that may contribute to patient decline and adverse outcomes (Morley, 2017; Soong et al., 2015; Warnier, van Rossum, van Leendert, et al., 2016). Nurses at the bedside can make important contributions to model development by being vigilant in their recognition and documentation of geriatric syndromes in the EHR and thereby filling data gaps with nursing-relevant data.

In clinical practice, the FRS risk factors (e.g., malnutrition, fatigue, weakness, dyspnea, dysphagia) may serve as useful, clinically relevant targets for individualized intervention strategies. Proactive intervention can help prevent cascade iatrogenesis (Thornlow et al., 2009) and a spiraling of adverse outcomes that arise from poor resilience to the hazards of hospitalization and exposure to the noxious effects of prolonged immobility, disrupted sleep, nothing-by-mouth (NPO), high-risk medications, and acquired infections (Schimmel, 2003). Determining which patients are at highest risk and would benefit the most from intensive

interventions and allocation of resources can be facilitated by using EHR data to classify high-risk patients using the FRS and remove the burden of extra data collection and manual calculations. Despite expected efficiencies from electronic documentation, nursing workload is strained by ever-increasing demands for electronic data entry; thus, any new data collection for clinical frailty assessment must be evaluated judiciously. As hospital informatics evolve, development of admission risk assessments and clinical decision support tools that incorporate frailty and comorbidity using existing data as described in the current study can be made available in real time to clinicians. Emerging technological advancements in body worn and environmental physiological sensing devices and other tools may provide effective, flexible, and integrative solutions for passive monitoring that may augment the frailty assessment (Zaslavsky et al., 2012). Using historical data and modeling patients with similar clinical features and health care use patterns may be useful as an admission screening tool to readily stratify patients into risk groups and facilitate timely and appropriately targeted measures that can be initiated during hospitalization.

Exploring factors associated with hospital readmission during critical time periods after discharge (earlier 3-day and 7-day versus later readmissions in the 30-day window) is crucial toward informing quality improvement initiatives to address the in-hospital component and patient readiness for discharge (Flaks-Manov et al., 2019). Transitional care interventions (e.g., medication reconciliation and counseling, post discharge follow-up phone calls, polypharmacy consult, therapy referrals, home health) and case management (Burke et al., 2016; Sandberg et al., 2015) can improve the management of complex care.

One caveat on using administrative billing and clinical EHR data is that ICD codes are used in risk prediction models and these often miss psychosocial and functional factors that contribute to the complexity of care and needs (Jeffery et al., 2019). Nurse researchers can identify and apply common data elements relevant to nursing across EHR systems in predictive models; including incorporation of International Classification of Nursing Practice codes in the EHR would capture some nuances that provide contextual information about patient health status and thereby improve the relevance and performance of the models (Jeffery et al., 2019). Future research will focus on mapping EHR clinical flowsheet data that are documented by nurses and other health care providers to the FRS, as these data may more accurately represent the frailty risk factors than ICD codes and improve model accuracy. These investigations will also test machine learning models to assess predictors of readmission and identify clusters of patient characteristics that show differences in which FRS and comorbidity combination indicate highest risk and the need for further assessment and nurse-intensive interventions.

CONCLUSION

There is a need for improvement of risk prediction models for hospital readmission. Prediction of readmission risk is valuable for hospitals as patient readmissions are a significant contributor to increased health care costs and total inpatient spending. The major findings from this study suggest that frailty and comorbidity are independently and significantly associated with readmission and in combined models outperform other predictive models using EHR data for unplanned all-cause readmission. The reliable characterization and detection of frailty using readily available EHR data are needed to inform clinical decision making and plan appropriate care.

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Table A

Frailty Risk Score (FRS) ICD-10-CM Codes

VARIABLE	Diagnosis	ICD-10-CM Codes	ICD-10-CM Code Description
Malnutrition	Nutritional marasmus, Malnutrition	E41	E41 nutritional marasmus, severe calorie malnutrition, emaciation
		E42	E42 kwashiorkor
		E43	E43 unspecified severe protein-calorie malnutrition
		E44.0	E44.0 moderate protein-calorie malnutrition
		E44.1	E44.1 mild protein-calorie malnutrition
		E46	E46 severe protein-calorie malnutrition,
		R63.0	R63.0 anorexia, loss of appetite
		R63.3	R63.3 feeding difficulties or problem
		E63.9	E63.9 diet causing nutritional deficiency
		R64	R64 cachexia
		T73.0	T73.0 starvation hunger effects, inanition (exhausted condition from lack of food and water) due to deprivation of food

Abnormal weight	Abnormal weight loss, Underweight, obesity	R63.4 R63.6 Z68.1 E66.0 E66.1 E66.2 E66.8 E66.9	R63.4 abnormal loss of weight R63.6 underweight Z68.1 BMI 19.9 or less E66. overweight and obesity E66.1 drug induced obesity E66.2 morbid obesity E66.8 other obesity E66.9 obesity unspecified
Dysphagia	Dysphagia	R13.0 R13.10 R13.11 R13.12 R13.13 R13.14 R13.19 I69.391 I69.891 I69.991	R13.0 aphagia, deglutition R13.10 dysphagia unspecified R13.11 dysphagia oral phase R13.12 dysphagia oropharyngeal phase R13.13 dysphagia pharyngeal phase R13.14 dysphagia pharyngoesophageal phase R13.19 other dysphagia (cervical dysphagia and neurogenic dysphagia) I69.391 dysphagia following cerebral infarction I69.891 dysphagia following other cerebrovascular disease I69.991 dysphagia following unspecified cerebrovascular disease

Delirium	Delirium	F05 F06.0 F10.231 F10.921 F11.921 F12.921 F13.921 F14.921 F15.921 F19.921 R41 R41.82	F05 delirium due to known physiological condition, general medical condition, post-procedural, multiple etiologies, unknown etiologies F06.0 transient organic psychotic with hallucinations F10.231 alcohol intoxication with withdrawal delirium, delirium tremens F10.921 alcohol use, unspecified with intoxication delirium F11.921 opioid intoxication with delirium 12.921 cannabis intoxication with delirium F13.921 delirium secondary to anxiolytic or hypnotic F14.921 delirium secondary to cocaine intoxication F15.921 delirium due to anxiolytic intoxication or stimulant induced F19.921 delirium secondary to unknown substance R41 delirium with dementia R41.82 changes in mental status

Dementia	Dementia	F01.50 F01.51 F02.80 F02.81 F03 F03.90 F03.91 F10.97 F13.97 F19.97 G30.8 G30.9 G31.83 G31.09 I69.81 I69.91 A81.0	F01.50 vascular–multi-infarct F01.51 vascular dementia with behavioral disturbance F02.80 dementia in other diseases classified elsewhere without behavioral disturbance F02.81 dementia in other diseases classified elsewhere with behavioral disturbance; Lewy bodies, Parkinson's and with behavioral disturbance F03 primary degenerative F03.90 degenerative primary; old age, persisting dementia w/o behavioral disturbance; Alzheimer's disease () F03.91 unspecified dementia with behavioral disturbance F10.97 alcohol-induced persisting dementia F13.97 dementia due to sedatives, hypnotics, or anxiolytics F19.97 other psychoactive substance use inducing persisting dementia G30.8 Alzheimer's disease G30.9 Alzheimer's disease with behavioral disturbance G31.83 dementia with Lewy bodies G31.09 frontal lobe, frontotemporal dementia I69.81 cognitive deficits following cerebrovascular disease I69.91 cognitive deficits following unspecified cerebrovascular disease A81.0 dementia due to Creutzfeldt-Jakob

Depression	Depression	F32.2 F32.3 F32.89 F32.9 F33.1 F33.2 F33.3 F33.9 F34.0 F34.1 F34.8 F34.9	F32.2 agitated, severe single episode F32.3 Major depressive w psychotic features F32.89 acute depression single episode F32.9 major depressive disorder; single episode w/o psychotic symptoms F33.1 moderate recurrent depressive episode F33.2 recurrent severe w/o psychotic features F33.3 recurrent depressive episode w psychotic symptoms F33.9 monopolar, recurrent F34.0 cyclothymic disorder F34.1 dysthymic disorder, persistent F34.8 Other persistent mood disorders F34.9 persistent mood disorder unspecified

Vision problems	Moderate or profound vision impairment, one or both eyes	H54.0 H54.10 H54.3 H54.40 H54.50 H54.60 H54.7 H54.8 H25.9 H26.1 H26.2 H26.3 H26.4 H26.8 E08.36 E09.36 E10.36 E11.36 E13.36 H40.1 H40.10 H40.11 H40.111 H40.11, H40.113 H40.119 H40.12 H40.121 H40.122 H40.123 H40.129	H54.0 blindness both eyes H54.10 blindness, one eye, low vision other eye H54.3 unqualified vision loss both eyes H54.40 blindness one eye H54.50 low vision, unspecified eye H54.60 unqualified vision loss, one eye H54.7 impaired vision, unspecified vision loss H54.8 legal blindness <u>Cataract</u> H25.9 age-related senile cataract H26.1 traumatic cataract H26.2 complicated cataract H26.30 drug-induced cataract, unspecified eye H26.4 other secondary cataract H26.8 other specific cataract E08.36 diabetes mellitus due to underlying condition with diabetic cataract E09.36 drug or chemical induced diabetes mellitus with diabetic cataract E10.36 Type 1 diabetes mellitus with diabetic cataract E11.36 Type 2 diabetes mellitus with diabetic cataract E13.36 other specified diabetes mellitus with diabetic cataract <u>Glaucoma</u> H40.1 open-angle glaucoma H40.10, H40.11, H40.111, H40.112, H40.113, H40.119 primary open angle glaucoma H40.12, H40.121, H40.122, H40.123, H40.129 low tension glaucoma

		H40.13, H40.131 H40.132 H40.133 H40.139	H40.13, H40.131, H40.132, H40.133, H40.139 pigmentary glaucoma
		H40.14, H40.141 H40.142 H40.143 H40.149	H40.14, H40.141, H40.142, H40.143, H40.149 capsular glaucoma with pseudo-exfoliation of lens, unspecified eye
		H40.15, H40.151 H40.152 H40.153 H40.159	H40.15, H40.151, H40.152, H40.153, H40.159 residual stage of open-angle glaucoma
		H40.2 H40.20 H40.21 H40.22 H40.23 H40.24	H40.2 H40.20, H40.21, H40.22, H40.23 H40.24 primary angle closure glaucoma
		H40.3 H40.30 H40.31 H40.32 H40.33	H40.3, H40.30, H40.31, H40.32, H40.33 glaucoma secondary to eye trauma
		H40.4 H40.40 H40.41 H40.42 H40.43	H40.4, H40.40 H40.41, H40.42, H40.43 glaucoma secondary to eye inflammation
		H40.5 H40.50 H40.51 H40.52 H40.53	H40.5 H40.50, H40.51, H40.52, H40.53 glaucoma secondary to other eye disorders
		H40.6 H40.60 H40.61	H40.6, H40.60, H40.6, H40.62, H40.63 H40.64 glaucoma secondary to drugs

		H40.62 H40.63 H40.8 H40.81 H40.82 H40.83 H40.89 H40.9	 H40.8, H40.81, H40.82, H40.83, H40.84 other glaucoma H40.9 unspecified glaucoma
		H35.30 H35.31 H35.311 H35.312 H35.313 H35.319 H35.32 H35.321 H35.322 H35.323 H35.329 H35.33 H35.34 H35.341 H35.342 H35.343 H35.349 H35.35 H35.351 H35.352 H35.353 H35.359 H35.36 H35.361 H35.362 H35.363 H35.369 H35.37 H35.371 H35.372	<u>Macular degeneration</u> H35.30 macular degeneration H35.31, H35.311, H35.312, H35.313, H35.319 nonexudative age-related macular degeneration H35.32, H35.321, H35.322, H35.323, H35.329 exudative age-related macular degeneration H35.33 angoid streaks H35.34, H35.341, H35.342, H35.343, H35.349 hole H35.35, H35.35, H35.352, H35.353, H35.359 cystoid H35.36, H35.361, H35.362, H35.363, H35.369 drusen H35.37, H35.371, H35.372, H35.373, H35.379 puckering

		H35.373 H35.379 H35.38 H35.381 H35.382 H35.383 H35.389	H35.38, H35.381, H35.382, H35.383, H35.389 toxic maculopathy
		H35.00	<u>Retinal disorders</u>
		H35.02 H35.021 H35.022 H35.023 H35.029	H35.00 Unspecified background retinopathy H35.02, H35.021, H35.022, H35.023, H35.029 exudative retinopathy
		H35.03 H35.031 H35.032 H35.033 H35.039	H35.03, H35.031, H35.032, H35.033, H35.039 hypertensive retinopathy
		H35.04 H35.041 H35.042 H35.043 H35.049	H35.04, H35.041, H35.042, H35.043, H35.049 retinal micro-aneurysms unspecified
		H35.05 H35.051 H35.052 H35.053 H35.059	H35.05, H35.051, H35.052, H35.053, H35.059 retinal neovascularization unspecified
		H35.06 H35.061 H35.062 H35.063 H35.069	H35.06 H35.061, H35.062, H35.063, H35.069 retinal vasculitis
		H35.07 H35.071 H35.072 H35.073 H35.079	H35.07, H35.071, H35.072, H35.073, H35.079 retinal telangiectasis

		H35.2 H35.20 H35.21 H35.22 H35.23	H35.2, H35.20, H35.21, H35.22, H35.23 other nondiabetic proliferative retinopathy
		H35.4 H35.40 H35.41 H35.42 H35.43 H35.44 H35.45 H35.46	H35.4, H35.40, H35.41, H35.42, H35.43, H35.44, H35.45, H35.46 peripheral retinal degeneration
		H35.5 H35.50 H35.51 H35.52 H35.53 H35.54	H35.5, H35.50, H35.51, H35.52, H35.53, H35.54 hereditary retinal dystrophy
		H35.6 H35.60 H35.61 H35.62 H35.63	H35.6 H35.60, H35.61, H35.62, H35.63 retinal hemorrhage
		H35.7 H35.70 H35.71 H35.711 H35.712 H35.713 H35.719	H35.7, H35.70, H35.71, H35.711, 35.712, H35.713, H35.719 separation of retinal layers
		H35.72 H35.721 H35.722 H35.723 H35.729	H35.72, H35.721, H35.722, H35.723, H35.729 serous detachment of retinal pigment epithelium
		H35.73 H35.731 H35.732	

		H35.733 H35.739 H35.8 H35.81 H35.82 H35.89 H35.719 H31.029 E11.319 E11.321 E11.329 E11.331 E11.339 E11.341 E11.349 E11.35 E11.351 E11.352 E11.353 E11.354 E11.355 E11.359 E09.311	H35.73, H35.731, H35.732, H35.733, H35.739 hemorrhagic detachment of retinal pigment epithelium H35.8, H35.81, H35.82, H35.89 other retinal disorders H35.719 Chorioretinopathy H31.029 Solar retinopathy <u>Diabetic retinopathy</u> E11.319 T2DM with unspecified retinopathy w/o macular edema E11.321 T2DM with mild nonproliferative retinopathy w macular edema E11.329 T2DM with mild nonproliferative retinopathy w/o macular edema, E11.331 T2DM with moderate nonproliferative retinopathy w macular edema E11.339 T2DM with moderate nonproliferative retinopathy w/o macular edema E11.341 T2DM with severe nonproliferative retinopathy with macular edema E11.349 T2DM with severe nonproliferative retinopathy w/o macular edema E11.35 T2DM w proliferative retinopathy, w and w/o retinal detachment, macular involvement E11.359 T2DM with proliferative retinopathy w/o macular edema E09.311 drug or chemical induced DM with unspecified retinopathy w macular edema

		E09.319	E09.319 drug or chemical induced DM with unspecified retinopathy w/o macular edema
		E09.331	E09.331 drug or chemical induced DM with moderate nonproliferative retinopathy w macular edema
		E09.339	E09.339 drug or chemical induced DM w moderate nonproliferative retinopathy w/o macular edema
		E09.341	E09.341 drug or chemical induced DM w severe nonproliferative retinopathy w macular edema
		E09.349	E09.349 drug or chemical induced DM with severe nonproliferative retinopathy w/o macular edema
		E08.319	E08.319 DM due to underlying condition with unspecified retinopathy w/o macular edema
		E08.311	E08.311 DM with unspecified retinopathy w macular edema
		E08.331	E08.331 DM due to underlying condition with moderate nonproliferative retinopathy w macular edema
		E08.339	E08.339 DM due to underlying condition with moderate nonproliferative retinopathy w/o macular edema
		E08.341	E08.341 DM due to underlying condition with severe nonproliferative retinopathy w macular edema
		E08.349	E08.349 DM due to underlying condition with severe nonproliferative retinopathy w/o macular edema
		E08.351	E08.351 DM due to underlying condition with proliferative retinopathy w macular edema,
		E08.352	E08.352 DM w retinopathy w retinal detachment
		E08.353	E08.353 DM w retinopathy and retinal detachment not involving macula
		E08.354	E08.354 DM and proliferative retinopathy w detachment
		E08.355	E08.355 DM w stable proliferative retinopathy
		E08.359	E08.359 DM due to underlying condition with proliferative diabetic retinopathy without macular

		E10.3	E10.3 T1DM with ophthalmic complications
		E10.311	E10.311 T1DM with unspecified retinopathy w macular edema
		E10.319	E10.319. T1DM with unspecified diabetic retinopathy w/o macular edema
		E10.331	E10.331 T1DM with moderate nonproliferative retinopathy macular edema
		E10.339	E10.339 T1DM with moderate nonproliferative retinopathy w/o macular edema
		E10.341	E10.341 T1DM with severe nonproliferative retinopathy with macular edema
		E10.349	E10.349 T1DM with severe nonproliferative retinopathy w/o macular edema
		E10.35	E10.35 T1DM with proliferative diabetic retinopathy
		E10.351	E10.351 T1DM with proliferative diabetic retinopathy w macular edema
		E10.352	E10.352 T1DM with proliferative diabetic retinopathy w traction retinal detachment involving macula
		E10.353	E10.353 T1DM w proliferative diabetic retinopathy w retinal detachment not involving macula
		E10.354	E10.354 T1DM w proliferative diabetic retinopathy w retinal detachment and rhegmatogenous retinal detachment
		E10.355	E10.355 T1DM w stable proliferative diabetic retinopathy
		E10.359	E10.359 T1DM w proliferative diabetic retinopathy without macular edema
Weakness	Weakness	M62.81	M62.81 muscle weakness, generalized
		M62.84	M62.84 sarcopenia
		R53.1	R53.1 weak or generalized weakness
		R53.81	R53.81 debility, physical deterioration, malaise
		R54	R54 age-related physical debility

Fatigue	Fatigue	F48.8 G93.3 R53.82 R53.83 M62.89	F48.8 mental or nervous exhaustion G93.3 post-viral fatigue syndrome R53.82 chronic fatigue R53.83 general, fatigue, exhaustion, lack of energy, lethargy M62.89 muscle fatigue
Dyspnea	Dyspnea	R06.0 R06.00 R06.01 R06.02 R06.03 R06.2 R06.4 R06.09 J44.9 J45.51 J45.52 J45.901 J45.902 J44.1 J80	R06.0 dyspnea R06.00 dyspnea unspecified R06.01 orthopnea R06.02 shortness of breath R06.03 acute respiratory R06.2 wheezing R06.4 hyperventilation R06.09 other forms J44.9 chronic obstructive breathing J45.51 severe persistent asthma w acute exacerbation J45.52 severe persistent asthma w status asthmaticus J45.901 asthma, dyspnea, bronchitis w acute exacerbation J45.902 asthma w status asthmaticus J44.1 chronic asthma with acute exacerbation J80 acute respiratory distress
Difficulty in walking	Difficulty in walking Abnormality of gait	R26.0 R26.1 R26.2 R26.81 R26.89 R26.9 R27.0 Z74.09	R26.0 ataxic, staggering gait R26.1 paralytic gait (complete, incomplete) R26.2 walking difficulty R26.81 unsteadiness R26.89 imbalance R26.9 difficulty walking; unsteadiness, gait abnormality R27.0 ataxia Z74.09 reduced or impaired mobility, dependence and need for care provider

Falls	Fall Fall on stairs, steps, from wheelchair	W05.0 W05.1 W05.2 W06 W07 W08 W10 W10.1 W10.9 W16.212 W18.1 W19 R29.6 Z91.81	W05.0 fall out of wheelchair, nonmoving W05.1 fall off scooter, nonmotorized W05.2 fall off scooter, motorized W06 fall out of bed W07 fall out of chair W08 fall out of furniture W10 fall on escalator W10.1 fall off sidewalk curb W10.9 fall off steps W16.212 fall in bathtub W18.1 fall off toilet W19 fall, accidental R29.6 falling or repeated falls Z91.81 history of falling, at risk for falling
Chronic pain	Chronic pain	G89.21 G89.22 G89.28 G89.29 G89.3 G89.4	G89.21 chronic pain due to trauma G89.22 chronic pain due to post-thoracotomy G89.28 chronic post-procedural or postoperative pain G89.29 other chronic pain G89.3 neoplasm related chronic pain G89.4 chronic pain syndrome
Incontinence of urine	Incontinence of urine	N39.42 N39.44 N39.45	N39.42 incontinence without sensory awareness N39.44 nocturnal enuresis N39.45 continuous leakage
Fecal incontinence	Fecal incontinence	R15.9	R15.9 anal sphincter incontinence or feces or rectal incontinence, full incontinence of feces

Decubitus ulcer	Decubitus ulcer	L89 L89.0 L89.000 L89.001 L89.002 L89.003 L89.004 L89.009 L89.01 L89.010 L89.011 L89.012 L89.013 L89.014 L89.019 L89.02 L89.020 L89.021 L89.022 L89.023 L89.024 L89.029 L89.1 L89.10 L89.100 L89.101 L89.102 L89.103 L89.104 L89.109 L89.11 L89.110 L89.111 L89.112 L89.113 L89.114 L89.119 L89.12 L89.120 L89.121 L89.122	L89 ulcer L89.0 pressure ulcer unspecified elbow L89.000 elbow, unstageable L89.001 stage1 L89.002 stage 2 L89.003 stage 3 L89.004 stage 4 L89.009 unspecified stage L89.01, L89.010, L89.011, L89.012, L89.013, L89.014, L89.019 right elbow L89.02, L89.020, L89.021, L89.022, L89.023, L89.024, L89.029 left elbow L89.1 pressure ulcer of back: unspecified, right upper back, left upper back, right lower back, left lower back L89.1, L89.10, L89.100, L89.101, L89.102, L89.103, L89.104, L89.109 L89.11, L89.110, L89.111, L89.112, L89.113, L89.114, L89.119 L89.12, L89.120, L89.121, L89.122, L89.123, L89.124, L89.129

		L89.123 L89.124 L89.129	
		L89.13 L89.130 L89.131 L89.132 L89.133 L89.134 L89.139	L89.13, L89.130, L89.131, L89.132, L89.133, L89.134, L89.139
		L89.14 L89.140 L89.141 L89.142 L89.143 L89.144 L89.149	L89.14, L89.140, L89.141, L89.142, L89.143, L89.144, L89.149
		L89.15 L89.150 L89.151 L89.152 L89.153 L89.154 L89.159	L89.15 coccyx, sacral region L89.15, L89.15, L89.150, L89.151, L89.152, L89.153, L89.154, L89.159
		L89.2 L89.20 L89.200 L89.201 L89.202 L89.203 L89.204 L89.209	L89.2 pressure ulcer of hip Unspecified: L89.2, L89.20, L89.200, L89.201, L89.202, L89.203, L89.204, L89.209
		L89.21 L89.210 L89.211 L89.212 L89.213 L89.214 L89.219	Right hip: L89.21, L89.210, L89.211, L89.212, L89.213, L89.214, L89.219
		L89.22	Left hip:

		L89.220 L89.221 L89.222 L89.223 L89.224 L89.229	L89.22, L89.220, L89.221, L89.222, L89.223, L89.224, L89.229
		L89.3 L89.30 L89.300 L89.301 L89.302 L89.303 L89.304 L89.309	L89.3 pressure ulcer of buttock L89.30 Unspecified: L89.3, L89.300, L89.301, L89.302, L89.303, L89.304, L89.309
		L89.31 L89.310 L89.311 L89.312 L89.313 L89.314 L89.319	L89.31 pressure ulcer right buttock: L89.31, L89.310, L89.311, L89.312, L89.313, L89.314, L89.319
		L89.32 L89.320 L89.321 L89.322 L89.323 L89.324 L89.329	L89.32 left buttock: L89.32, L89.320, L89.321, L89.322, L89.323, L89.324, L89.329
		L89.4 L89.40 L89.41 L89.42 L89.43 L89.44 L89.45	L89.4 contiguous back, buttock and hip L89.4, L89.40, L89.41, L89.42, L89.43, L89.44, L89.45
		L89.5 L89.50 L89.500 L89.501 L89.502 L89.503	L89.5 pressure ulcer of ankle Unspecified: L89.5, L89.50, L89.500, L89.501, L89.502, L89.503, L89.504, L89.505

		L89.504 L89.505	
		L89.51 L89.510 L89.511 L89.512 L89.513 L89.514 L89.519	Right ankle: L89.51, L89.510, L89.511, L89.512, L89.513, L89.514, L89.519
		L89.52 L89.520 L89.521 L89.522 L89.523 L89.524 L89.529	Left ankle: L89.52, L89.520, L89.521, L89.522, L89.523, L89.524, L89.529
		L89.6 L89.60 L89.600 L89.601 L89.602 L89.603 L89.604 L89.609	L89.6 pressure ulcer of heel L89.60 unspecified: L89.60, L89.600, L89.601, L89.602, L89.603, L89.604, L89.609,
		L89.61 L89.610 L89.611 L89.612 L89.613 L89.614 L89.619	L89.61 right heel: L89.61, L89.610, L89.611, L89.612, L89.613, L89.614, L89.619
		L89.62 L89.620 L89.621 L89.622 L89.623 L89.624 L89.629	L89.62 left heel: L89.62, L89.620, L89.621, L89.622, L89.623, L89.624, L89.629
		L89.8 L89.81	L89.8 pressure ulcer of other site L89.81 head:

		L89.810 L89.811 L89.812 L89.813 L89.814 L89.819 L89.89 L89.890 L89.891 L89.892 L89.893 L89.894 L89.899 L89.9 L89.90 L89.91 L89.92 L89.93 L89.94 L89.95	L89.81, L89.810, L89.811, L89.812, L89.813, L89.814, L89.819 L89.89 pressure ulcer of other site: L89.89, L89.890, L89.891, L89.892, L89.893, L89.894, L89.899 L89.9 pressure ulcer unspecified site: L89.9, L89.90, L89.91, L89.92, L89.93, L89.94, L89.95
Material resources	Material resources	 Z59.0 Z59.1 Z59.4 Z59.5 Z59.6 Z59.7 Z59.8 Z59.9 Z60.2	<u>Lack of Adequate Housing and Material Resources</u> Z59.0 homelessness, shelter, migrant, transient Z59.1 inadequate housing, space, temporary, heating Z59.4 inadequate food supply Z59.5 housing circumstances affecting care, specified, extreme poverty Z59.6 lack of financial resources Z59.7 insufficient social insurance and welfare support Z59.8 problems related to housing and economic circumstances, isolation Z59.9 problems related to housing and economic circumstances affecting care, inadequate material resources Z60.2 problems related to living alone

Social Support	Social support	 Z60.4 Z63.8 Z63.9 Z65.8 Z65.9 Z74.2 Z55.0 Z55.8 Z55.9	<u>Social Support</u> Z60.4 social exclusion, isolation, rejection Z63.8 family discord or disruption Z63.9 problems related to family or primary support group; conflict or discord Z65.8 other problems related to psychosocial circumstances Z65.9 problem related to specific psychosocial circumstances Z74.2 dependence on care provider, or no household member able to render care Z55.0 illiteracy, low-level literacy Z55.8 problems related to education and literacy Z55.9 problems related to education and literacy
Smoking	Tobacco use	Z72.0 Z87.891 F17.2 F17.20 F17.21 F17.22 F17.29	Z72.0 tobacco use Z87.891 history of nicotine/tobacco dependence F17.2 nicotine dependence F17.20 nicotine dependence unspecified F17.21 cigarettes F17.22 chewing tobacco F17.29 nicotine dependence, other tobacco product
Blood Biomarkers			

WBC	High WBC	D72.820 D72.821 D72.822 D72.823 D72.824 D72.825 D72.828 D72.82	D72.820 lymphocytosis D72.821 monocytosis (symptomatic) D72.822 plasmacytosis (symptomatic) D72.823 leukemoid reaction D72.824 basophilia D72.825 bandemia D72.828 other elevated WBC D72.829 elevated WBC unspecified
	Low WBC Disorders of WBC	D70 D70.1 D70.2 D70.3 D70.4 D70.8 D70.9 D72.81 D72.810 D72.818 D72.819 D72.89 D72.9	D70 congenital agranulocytosis D70.1 Agranulocytosis secondary to cancer chemotherapy D70.2 other drug-induced agranulocytosis D70.3 neutropenia due to infection D70.4 cyclic neutropenia D70.8 other neutropenia D70.9 neutropenia unspecifiedD72.81 decreased WBC D72.810 lymphocytopenia D72.818 other decreased WBC D72.819 decreased WBC unspecified D72.89 Other specified disorders of white blood cells D72.9 disorder of white blood cells
Albumin	Low albumin	R77.0 E88.09	R77.0 abnormality of albumin E88.09 Hypoalbuminemia
CRP	High CRP	R79.82	R79.82 CRP elevated
Hemoglobin	Anemia	D50 D50.8 D50.9 D51.0 D51.1 D51.2 D51.3 D51.8 D51.9 D52.0 D52.1	D50 chronic blood loss anemia D50.8 iron deficiency anemia, poor absorption D50.9 iron deficiency anemia unspecified D51.0 vitamin B12 deficiency anemia due to intrinsic factor deficiency D51.1 vitamin B12 deficiency anemia due to malabsorption D51.2 transcobalamin II deficiency D51.3 other dietary vitamin B12 deficiency anemia D51.8 other vitamin B12 deficiency anemias D51.9 vitamin B12 deficiency anemia unspecified D52.0 dietary folate deficiency anemia

		D52.8 D52.9 D53.0 D53.1 D53.2 D53.8 D53.9 D62 D63.1 D64 D64.81 D64.9	D52.1 drug induced folate deficiency anemia D52.8 other folate deficiency anemias D52.9 folate deficiency anemia D53.0 protein deficiency anemia D53.1 other megaloblastic anemias D53.2 scorbutic anemia D53.8 other nutritional anemias D53.9 nutritional anemia unspecified D62 post hemorrhagic anemia D63.1 chronic kidney disease D64 other anemias D64.81 anemia due to antineoplastic chemotherapy D64.9 anemia unspecified
Glucose	High or abnormal glucose	R73 R73.0 R73.01 R73.02 R73.09 R73.9	R73 elevated blood glucose level R73.0 abnormal glucose R73.01 elevated fasting glucose R73.02 prediabetes R73.09 other abnormal glucose R73.9 hyperglycemia, unspecified
Creatinine clearance	Abnormal creatinine clearance	R94.4	R94.4 creatinine clearance abnormal
Sodium	High or low sodium	E87.0 E87.1	E87.0 hyperosmolality and hypernatremia E87.1 hypoosmolality and hyponatremia

Table B

Laboratory Reference Range for Blood Biomarkers

Biomarker	Reference Range	*n* (%) out of range
Albumin	3.5-5.0 g/dL	15,080 (27.0)
Creatinine	0.6-1.24 mg/dL	15,311 (27.5)
C-reactive protein	< 1 mg/dL	179 (0.3)
Glucose	65-99 mg/dL	44,332 (79.5)
Hemoglobin	female 12-15 g/dL male 13-17 g/dL	26,495 (47.5)
Sodium	135-145 mmol/L	11,299 (20.3)
White blood cell count (WBC)	4-10.5 K/uL	21,760 (39.0)

Table C

Comparison Between the Charlson and Elixhauser Comorbidity Indices.*

Charlson (CCI-17)	Charlson (CCI-12)**	Elixhauser (ECI)
Cardiovascular		
Myocardial infarction	Excluded	
Congestive heart failure	X	Congestive heart failure
		Arrhythmias
		Valvular disease
Vascular		Disease of pulmonary circulation
Peripheral vascular disease	Excluded	Peripheral vascular disease
		Hypertension
Neurologic		
Hemiplegia or paraplegia	X	Paralysis
Cerebrovascular disease	Excluded	Other neurologic disorders
Dementia	X	
Pulmonary		
Chronic pulmonary disease	X	Chronic pulmonary disease
Immunologic		
Rheumatologic disease	X	Rheumatoid arthritis
Gastrointestinal		
Peptic ulcer disease	Excluded	Peptic ulcer disease
Endocrine		
Diabetes without chronic complications	Excluded	Diabetes mellitus
Diabetes with chronic complications	X	Diabetes mellitus with complications
		Hypothyroidism
Renal		
Renal disease	X	Renal failure
Oncology		
Any malignancy including leukemia and lymphoma	X	Solid tumor without metastasis
Metastatic solid tumor	X	Metastatic cancer
		Lymphoma
Liver		
Mild liver disease	X	Liver disease
Moderate or severe liver disease	X	
Other		
HIV or AIDS	X	AIDS
		Coagulopathy
		Obesity

		Weight loss
		Fluid and electrolyte disorders
		Chronic blood loss anemia
		Deficiency anemias
		Alcohol abuse
		Drug abuse
		Psychosis
		Depression

*Charlson et al. (1987); Elixhauser et al. (1998)

**Charlson CCI-12 includes all CCI-17 comorbidities as indicated X except noted exclusions.

Table D

First Hospitalization and Patient Characteristics by Readmission Status

Characteristic *M* ± *SD* (*Min, Max*) or *n* (%)	Overall (*N* = 55,778)	0-3 days Readmission *n* = 1,728 (3.1%)	0-7 days Readmission *n* = 2,209 (4.0%)	0-30 days Readmission *n* = 3,748 (6.7%)	No 30-day Readmission *n* = 52,030 (93.3%)
Age at index admission	68.9 ± 11.3 (50, over 89)	69.1 ± 11.5 (50, over 89)	69.7 ± 11.5 (50, over 89)	70.5 ± 11.6 (50, over 89)	68.8 ± 11.3 (50, over 89)
Age decades					
50-<60 years	14,500 (26.0)	443 (25.6)	535 (24.2)	841 (22.4)	13,659 (26.3)
60-<70 years	16,658 (29.9)	510 (29.5)	632 (28.6)	1,022 (27.3)	15,636 (30.1)
70-<80 years	13,445 (24.1)	406 (23.5)	536 (24.3)	930 (24.8)	12,515 (24.1)
≥80 years	11,175 (20.0)	369 (21.4)	506 (22.9)	955 (25.5)	10,220 (19.6)
Sex					
Female	29,744 (53.3)	823 (47.6)	1,081 (48.9)	1,844 (49.2)	27,900 (53.6)
Male	26,034 (46.7)	905 (52.4)	1,128 (51.1)	1,904 (50.8)	24,130 (46.4)
Race/Ethnicity					
Non-Hispanic White	40,592 (72.8)	1,212 (70.1)	1,555 (70.4)	2,666 (71.1)	37,926 (72.9)
Non-Hispanic Black	12,621 (22.6)	419 (24.3)	535 (24.2)	895 (23.9)	11,726 (22.5)
Hispanic	600 (1.1)	19 (1.1)	25 (1.1)	42 (1.1)	558 (1.1)
Non-Hispanic Other	1,321 (2.4)	49 (2.8)	59 (2.7)	96 (2.6)	1,225 (2.4)
Declined /Unavailable	644 (1.2)	29 (1.7)	35 (1.6)	49 (1.3)	595 (1.1)
Hospital Site					
Site 1	5,565 (10.0)	130 (7.5)	187 (8.5)	400 (10.7)	5,165 (9.9)
Site 2	1,063 (1.9)	7 (0.4)	14 (0.6)	36 (1.0)	1,027 (2.0)
Site 3	34,755 (62.3)	1,269 (73.4)	1,577 (71.4)	2,464 (65.7)	32,291 (62.1)
Site 4	14,119 (25.3)	321 (18.6)	429 (19.4)	844 (22.5)	13,275 (25.5)
Site 5	276 (0.5)	1 (0.1)	2 (0.1)	4 (0.1)	272 (0.5)
Marital status					
Married/partnered/ significant other	29,332 (52.6)	884 (51.2)	1,114 (50.4)	1,831 (48.9)	27,501 (52.9)
Single	8,603 (15.4)	295 (17.1)	369 (16.7)	619 (16.5)	7,984 (15.3)
Divorced/separated	7,141 (12.8)	200 (11.6)	250 (11.3)	460 (12.3)	6,681 (12.8)
Widowed	10,113 (18.1)	316 (18.3)	437 (19.8)	786 (21.0)	9,327 (17.9)
Unknown/missing	589 (1.1)	33 (1.9)	39 (1.8)	52 (1.4)	537 (1.0)
Living status-lives alone	11,611 (20.8)	369 (21.4)	461 (20.9)	805 (21.5)	10,806 (20.8)
missing	8,019 (14.4)	190 (11.0)	277 (12.5)	558 (14.9)	7,461 (14.3)
Insurance payer					
Medicaid (Primary)	2,235 (4.0)	143 (8.3)	161 (7.3)	252 (6.7)	1,983 (3.8)
Medicare (Primary)	30,561 (54.8)	954 (55.2)	1,265 (57.3)	2,231 (59.5)	28,330 (54.5)
Dual Medicaid/Medicare	4,366 (7.8)	133 (7.7)	176 (8.0)	343 (9.2)	343 (9.2)
Self-pay/no charge	2,010 (3.6)	61 (3.5)	78 (3.5)	108 (2.9)	1,902 (3.7)
Private/other	16,606 (29.8)	437 (25.3)	529 (24.0)	814 (21.7)	15,792 (30.4)
Length of stay (days)	4.3 ± 3.8 (1.0, 103.6)	6.0 ± 5.0 (1.0, 42.1)	5.9 ± 4.8 (1.0, 42.1)	5.9 ± 5.1 (1.0, 74.0)	4.2 ± 3.7 (1.0, 103.6)

Characteristic *M* ± *SD* (*Min, Max*) or *n* (%)	Overall (*N* = 55,778)	0-3 days Readmission *n* = 1,728 (3.1%)	0-7 days Readmission *n* = 2,209 (4.0%)	0-30 days Readmission *n* = 3,748 (6.7%)	No 30-day Readmission *n* = 52,030 (93.3%)
Emergent admission	32,781 (58.8)	1,296 (75.0)	1,646 (74.5)	2,783 (74.3)	29,998 (57.7)
Has a primary care provider*	39,192 (70.3)	1,185 (68.6)	1,531 (69.3)	2,663 (71.1)	36,529 (70.2)
missing	12,823 (23.0)	370 (21.4)	472 (21.4)	778 (20.8)	12,045 (23.2)
Sees primary care provider regularly	36,714 (65.8)	1,124 (65.1)	1,453 (65.8)	2,552 (68.1)	34,162 (65.7)
missing	16,119 (28.9)	498 (28.8)	625 (28.3)	983 (26.2)	15,136 (29.1)
Pre-admission residence					
Home	49,689 (89.1)	1,553 (89.9)	1,955 (88.5)	3,240 (86.5)	46,449 (89.3)
Assisted living/Group home	1,464 (2.6)	47 (2.7)	67 (3.0)	145 (3.9)	1,319 (2.5)
Skilled nursing facility/ nursing home	1,389 (2.5)	31 (1.8)	52 (2.4)	122 (3.3)	1,267 (2.4)
Shelter/homeless	268 (0.5)	14 (0.8)	18 (0.8)	33 (0.9)	235 (0.5)
Other	641 (1.2)	23 (1.3)	36 (1.6)	63 (1.7)	578 (1.1)
Multiple	203 (0.4)	8 (0.5)	10 (0.5)	14 (0.4)	189 (0.4)
missing	2,124 (3.8)	52 (3.0)	71 (3.2)	131 (3.5)	1,993 (3.8)
Frailty Risk Score*					
1. FRS-18-Labs (*n*=30,791)	2.7 ± 1.7	2.7 ± 1.7	2.8 ± 1.7	3.0 ± 1.7	2.7 ± 1.7
2. FRS-21-Labs (*n*=30,753)	4.1 ± 2.0	4.2 ± 2.0	4.3 ± 2.0	4.5 ± 2.0	4.1 ± 2.0
3. FRS-25-Labs (*n*=30,753)	4.3 ± 2.1	4.4 ± 2.1	4.6 ± 2.2	4.8 ± 2.2	4.3 ± 2.1
4. FRS-19-ICD (*n*=55,098)	1.3 ± 1.5	1.6 ± 1.5	1.6 ± 1.6	1.7 ± 1.6	1.3 ± 1.5
5. FRS-26-ICD (*n*=55,098)	1.8 ± 1.8	2.3 ± 1.9	2.3 ± 1.9	2.4 ± 1.9	1.8 ± 1.8
Charlson Comorbidity Index (CCI-17) (Quan et al., 2005)	1.8 ± 2.2 (0, 17)	2.4 ± 2.4 (0, 15)	2.5 ± 2.4 (0, 15)	2.6 ± 2.6 (0, 17)	1.7 ± 2.1 (0, 16)
missing	1,382 (2.5)	5 (0.3)	10 (0.5)	22 (0.6)	1,360 (2.6)
Charlson Comorbidity Index (CCI-12) (Quan et al., 2011)	1.3 ± 1.9 (0, 15)	1.6 ± 2.1 (0, 15)	1.7 ± 2.2 (0, 15)	1.9 ± 2.3 (0, 15)	1.2 ± 1.9 (0, 13)
missing	1,382 (2.5)	5 (0.3)	10 (0.5)	22 (0.6)	1,360 (2.6)
Elixhauser Comorbidity Index (ECI)	3.1 ± 2.4 (0, 17)	3.7 ± 2.2 (0, 12)	3.8 ± 2.2 (0, 12)	4.0 ± 2.3 (0, 14)	3.0 ± 2.4 (0, 17)
missing	1,382 (2.5)	5 (0.3)	10 (0.5)	22 (0.6)	1,360 (2.6)
Common comorbidities					
Hypertension					
uncomplicated	31,805 (57.0)	1,154 (66.8)	1,472 (66.6)	2,431 (64.9)	29,374 (56.5)
complicated	1,371 (2.5)	41 (2.4)	57 (2.6)	112 (3.0)	1,259 (2.4)
Cardiovascular disease	8,495 (15.2)	647 (37.4)	744 (33.7)	1,019 (27.2)	7,476 (14.4)
Congestive heart failure	9,187 (16.5)	319 (18.5)	445 (20.1)	874 (23.3)	8,313 (16.0)
Peripheral vascular disease	6,171 (11.1)	192 (11.1)	275 (12.5)	520 (13.9)	5,651 (10.9)
Stroke (Li et al., 2008)	5,958 (10.7)	557 (32.2)	627 (28.4)	827 (22.1)	5,131 (9.9)
Myocardial infarction	3,949 (7.1)	117 (6.8)	167 (7.6)	288 (7.7)	3,661 (7.0)
Chronic pulmonary disease	1,425 (2.6)	45 (2.6)	61 (2.8)	125 (3.3)	1,300 (2.5)
Diabetes mellitus					
without complications	12,372 (22.2)	452 (26.2)	588 (26.6)	998 (26.6)	11,374 (21.9)
with complications	3,460 (6.2)	158 (9.1)	206 (9.3)	313 (8.4)	3,147 (6.1)
Chronic renal disease	7,208 (12.9)	286 (16.6)	397 (18.0)	733 (19.6)	6,475 (12.4)

Characteristic *M* ± *SD* (*Min, Max*) or *n* (%)	Overall (*N* = 55,778)	0-3 days Readmission *n* = 1,728 (3.1%)	0-7 days Readmission *n* = 2,209 (4.0%)	0-30 days Readmission *n* = 3,748 (6.7%)	No 30-day Readmission *n* = 52,030 (93.3%)
Malignant disease	6,437 (11.5)	192 (11.1)	273 (12.4)	599 (16.0)	5,838 (11.2)
metastatic disease	1,773 (3.2)	75 (4.3)	105 (4.8)	241 (6.4)	1,532 (2.9)
Liver disease					
mild	1,806 (3.2)	59 (3.4)	80 (3.6)	159 (4.2)	1,647 (3.2)
moderate/severe	345 (0.6)	12 (0.7)	18 (0.8)	46 (1.2)	299 (0.6)
missing comorbidities	1,382 (2.5)	5 (0.3)	10 (0.5)	22 (0.6)	1,360 (2.6)
Polypharmacy (takes 7+ prescribed medications)	18,894 (33.9)	553 (32.0)	750 (34.0)	1,406 (37.5)	17,488 (33.6)
missing	13,054 (23.4)	376 (21.8)	481 (21.8)	802 (21.4)	12,252 (23.6)
Initial discharge disposition					
Home, no services	31,967 (57.3)	401 (23.2)	655 (29.7)	1,376 (36.5)	30,600 (58.8)
Home, with services	11,123 (19.9)	139 (8.0)	221 (10.0)	505 (13.5)	10,618 (20.4)
Hospice	1,226 (2.2)	33 (1.9)	36 (1.6)	53 (1.4)	1,173 (2.3)
Skilled nursing facility	9,722 (17.4)	144 (8.3)	278 (12.6)	782 (20.9)	8,940 (17.2)
Rehabilitation hospital	925 (1.7)	841 (48.7)	841 (38.1)	844 (22.5)	81 (0.2)
Another hospital	375 (0.7)	115 (6.7)	116 (5.3)	121 (3.2)	254 (0.5)
Other	440 (0.8)	55 (3.2)	62 (2.8)	76 (2.0)	364 (0.7)
Discharge timing, 1st admit					
0800-1259	17,417 (31.2)	227 (13.1)	333 (15.1)	689 (18.4)	16,728 (32.2)
1300-1759	32,828 (58.9)	1,193 (69.0)	1,505 (68.1)	2,492 (66.5)	30,336 (58.3)
1800-0759	5,533 (9.9)	308 (17.8)	371 (16.7)	567 (15.1)	4,966 (9.5)
Top 1st Admission Reasons (Primary problem)					
1. M17.10/.11/.12 Osteoarth	1,622 (2.9)	22 (1.3)	23 (1.0)	29 (0.8)	1,593 (3.1)
2. R07.9 Chest pain, unspec	1,126 (2.0)	20 (1.2)	28 (1.3)	55 (1.5)	1,071 (2.1)
3. I63.9 Cerebral infarction	912 (1.6)	134 (7.8)	141 (6.4)	169 (4.5)	743 (1.4)
4. J18.9 Pneumonia	917 (1.6)	32 (1.9)	42 (1.9)	97 (2.6)	820 (1.6)
5. A41.9 Sepsis	895 (1.6)	21 (1.2)	31 (1.4)	84 (2.2)	811 (1.7)
6. R55 Syncope and collaps	774 (1.4)	28 (1.6)	40 (1.8)	56 (1.5)	718 (1.4)
7. I21.4 NSTEMI MI	673 (1.2)	18 (1.0)	24 (1.1)	41 (1.1)	632 (1.2)
8. K92.2 Gastroint hemorrh	565 (1.0)	15 (0.9)	22 (1.0)	56 (1.5)	509 (1.0)
9. J96.01 Ac. resp. fail hyp	552 (1.0)	16 (0.9)	31 (1.4)	59 (1.6)	493 (1.0)
10. G93.40 Encephalopathy	512 (0.9)	25 (1.5)	33 (1.5)	67 (1.8)	445 (0.9)

Note. *Primary care provider (PCP) includes health professional such as physician, nurse practitioner, physician's assistant.