Numeracy, Health Literacy, Cognition, and 30-Day Readmissions among Patients with Heart Failure

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BACKGROUND: Numeracy, health literacy, and cognition are important for chronic disease management. Prior studies have found them to be associated with poorer self-care and worse clinical outcomes, but limited data exists in the context of heart failure (HF), a condition that requires patients to monitor their weight, fluid intake, and dietary salt, especially in the posthospitalization period.

OBJECTIVE: To examine the relationship between numeracy, health literacy, and cognition with 30-day readmissions among patients hospitalized for acute decompensated HF (ADHF).

DESIGN/SETTING/PATIENTS: The Vanderbilt Inpatient Cohort Study is a prospective longitudinal study of adults hospitalized with acute coronary syndromes and/or ADHF. We studied 883 adults hospitalized with ADHF.

MEASUREMENTS: During their hospitalization, a baseline interview was performed in which demographic characteristics, numeracy, health literacy, and cognition were assessed. Through chart review, clinical characteristics were determined. The outcome of interest was 30-day readmission to any acute care hospital. To examine the association between numeracy, health literacy, cognition, and 30-day readmissions, multivariable Poisson (log-linear) regression was used.

RESULTS: Of the 883 patients admitted for ADHF, 23.8% (n = 210) were readmitted within 30 days; 33.9% of the study population had inadequate numeracy skills, 24.6% had inadequate/marginal literacy skills, and 53% had any cognitive impairment. Numeracy and cognition were not associated with 30-day readmissions. Though (objective) health literacy was associated with 30-day readmissions in unadjusted analyses, it was not in adjusted analyses.

CONCLUSIONS: Numeracy, health literacy, and cognition were not associated with 30-day readmission among this sample of patients hospitalized with ADHF. *Journal of Hospital Medicine* 2018;13:145-151. Published online first February 12, 2018. © 2018 Society of Hospital Medicine

Most studies to identify risk factors for readmission among patients with heart failure (HF) have focused on demographic and clinical characteristics.[1,2] Although easy to extract from administrative databases, this approach fails to capture the complex psychosocial and cognitive factors that influence the ability of HF patients to manage their disease in the postdischarge period, as depicted in the framework by Meyers et al.[3] (2014). To date, studies have found low health literacy, decreased social support, and cognitive impairment to be associated with health behaviors and outcomes among HF patients, including decreased self-care,[4] low HF-specific knowledge,[5] medication nonadherence,[6] hospitalizations,[7] and mortality.[8-10] Less, however, is known about the effect of numeracy on HF outcomes, such as 30-day readmission.

Numeracy, or quantitative literacy, refers to the ability to access, understand, and apply numerical data to health-related decisions.[11] It is estimated that 110 million people in the United States have limited numeracy skills.[12] Low numeracy is a risk factor for poor glycemic control among patients with diabetes,[13] medication adherence in HIV/AIDS,[14] and worse blood pressure control in hypertensives.[15] Much like these conditions, HF requires that patients understand, use, and act on numerical information. Maintaining a low-salt diet, monitoring

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Additional Supporting Information may be found in the online version of this article.

Received: June 5, 2017; **Revised**: October 24, 2017; **Accepted**: November 11, 2017

2018 Society of Hospital Medicine DOI 10.12788/jhm.2932

weight, adjusting diuretic doses, and measuring blood pressure are tasks that HF patients are asked to perform on a daily or near-daily basis. These tasks are particularly important in the posthospitalization period and could be complicated by medication changes, which might create additional challenges for patients with inadequate numeracy. Additionally, cognitive impairment, which is a highly prevalent comorbid condition among adults with HF,[16,17] might impose additional barriers for those with inadequate numeracy who do not have adequate social support. However, to date, numeracy in the context of HF has not been well described.

Herein, we examined the effects of numeracy, alongside health literacy and cognition, on 30-day readmission risk among patients hospitalized for acute decompensated HF (ADHF).

METHODS

Study Design

The Vanderbilt Inpatient Cohort Study (VICS) is a prospective observational study of patients admitted with cardiovascular disease to Vanderbilt University Medical Center (VUMC), an academic tertiary care hospital. VICS was designed to investigate the impact of social determinants of health on postdischarge health outcomes. A detailed description of the study rationale, design, and methods is described elsewhere.[3]

Briefly, participants completed a baseline interview while hospitalized, and follow-up phone calls were conducted within 1 week of discharge, at 30 days, and at 90 days. At 30 and 90 days postdischarge, healthcare utilization was ascertained by review of medical records and patient report. Clinical data about the index hospitalization were also abstracted. The Vanderbilt University Institutional Review Board approved the study.

Study Population

Patients hospitalized from 2011 to 2015 with a likely diagnosis of acute coronary syndrome and/or ADHF, as determined by a physician's review of the medical record, were identified as potentially eligible. Research assistants assessed these patients for the presence of the following exclusion criteria: less than 18 years of age, non-English speaking, unstable psychiatric illness, a low likelihood of follow-up (eg, no reliable telephone number), on hospice, or otherwise too ill to complete an interview. Additionally, those with severe cognitive impairment, as assessed from the medical record (such as seeing a note describing dementia), and those with delirium, as assessed by the brief confusion assessment method, were excluded from enrollment in the study.[18,19] Those who died before discharge or during the 30-day follow-up period were excluded. For this analysis, we restricted our sample to only include participants who were hospitalized for ADHF.

Outcome Measure: 30-Day Readmission

The main outcome was all-cause readmission to any hospital within 30 days of discharge, as determined by patient interview, review of electronic medical records from VUMC, and review of outside hospital records.

Main Exposures: Numeracy, Health Literacy, and Cognitive Impairment

Numeracy was assessed with a 3-item version of the Subjective Numeracy Scale (SNS-3), which quantifies the patients perceived quantitative abilities.[20] Other authors have shown that the SNS-3 has a correlation coefficient of 0.88 with the full-length SNS-8 and a Cronbach's alpha of 0.78.[20-22] The SNS-3 is reported as the mean on a scale from 1 to 6, with higher scores reflecting higher numeracy.

Subjective health literacy was assessed by using the 3-item Brief Health Literacy Screen (BHLS).[23] Scores range from 3 to 15, with higher scores reflecting higher literacy. Objective health literacy was assessed with the short form of the Test of Functional Health Literacy in Adults (sTOFHLA).[24,25] Scores may be categorized as inadequate (0-16), marginal (17-22), or adequate (23-36).

We assessed cognition by using the 10-item Short Portable Mental Status Questionnaire (SPMSQ).[26] The SPMSQ, which describes a person's capacity for memory, structured thought, and orientation, has been validated and has demonstrated good reliability and validity.[27] Scores of 0 were considered to reflect intact cognition, and scores of 1 or more were considered to reflect any cognitive impairment, a scoring approach employed by other authors.[28] We used this approach, rather than the traditional scoring system developed by Pfeiffer et al.[26] (1975), because it would be the most sensitive to detect any cognitive impairment in the VICS cohort, which excluded those with severe cognition impairment, dementia, and delirium.

Covariates

During the hospitalization, participants completed an in-person interviewer-administered baseline assessment composed of demographic information, including age, self-reported race (white and nonwhite), educational attainment, home status (married, not married and living with someone, not married and living alone), and household income.

Clinical and diagnostic characteristics abstracted from the medical record included a medical history of HF, HF subtype (classified by left ventricular ejection fraction [LVEF]), coronary artery disease, chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM), and comorbidity burden as summarized by the van Walraven-Elixhauser score.[29,30] Depressive symptoms were assessed during the 2 weeks prior to the hospitalization by using the first 8 items of the Patient Health Questionnaire.[31] Scores ranged from 0 to 24, with higher scores reflecting more severe depressive symptoms. Laboratory values included estimated glomerular filtration rate (eGFR), hemoglobin (g/dl), sodium (mg/L), and brain natriuretic peptide (BNP) (pg/ml) from the last laboratory draw before discharge. Smoking status was also assessed (current and former/nonsmokers).

Hospitalization characteristics included length of stay in days, number of prior admissions in the last year, and transfer to the intensive care unit during the index admission.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. The Kruskal-Wallis test and the Pearson χ^2 test were

used to determine the association between patient characteristics and levels of numeracy, literacy, and cognition separately. The unadjusted relationship between patient characteristics and 30-day readmission was assessed by using Wilcoxon rank sums tests for continuous variables and Pearson χ^2 tests for categorical variables. In addition, a correlation matrix was performed to assess the correlations between numeracy, health literacy, and cognition (supplementary Figure 1).

To examine the association between numeracy, health literacy, and cognition and 30-day readmissions, a series of multivariable Poisson (log-linear) regression models were fit.[32] Like other studies, numeracy, health literacy, and cognition were examined as categorical and continuous measures in models.[33] Each model was modified with a sandwich estimator for robust standard errors. Log-linear models were chosen over logistic regression models for ease of interpretation because (exponentiated) parameters correspond to risk ratios (RRs) as opposed to odds ratios. Furthermore, the fitting challenges associated with log-linear models when predicted probabilities are near 0 or 1 were not present in these analyses. Redundancy analyses were conducted to ensure that independent variables were not highly correlated with a linear combination of the other independent variables. To avoid case-wise deletion of records with missing covariates, we employed multiple imputation with 10 imputation samples by using predictive mean matching.[34,35] All analyses were conducted in R version 3.1.2 (The R Foundation, Vienna, Austria).[36]

RESULTS

Overall, 883 patients were included in this analysis (supplementary Figure 2). Of the 883 participants, 46% were female and 76% were white (Table 1). Their median age was 60 years (interdecile range [IDR] 39-78) and the median educational attainment was 13.5 years (IDR 11-18).

Characteristics of the study sample by levels of subjective numeracy, objective health literacy, and cognition are shown in Table 1. A total of 33.9% had inadequate health numeracy (SNS scores 1-3 on a scale of 1-6) with an overall mean subjective numeracy score of 4.3 (standard deviation ± 1.3). Patients with inadequate numeracy were more likely to be women, nonwhite, and have lower education and income. Overall, 24.6% of the study population had inadequate/marginal objective health literacy, which is similar to the 26.1% with inadequate health literacy by the subjective literacy scale (BHLS scores 3-9 on a scale of 3-15) (supplementary Table 1). Patients with inadequate objective health literacy were more likely to be older, nonwhite, have less education and income, and more comorbidities compared with those with marginal/adequate health literacy. Overall, 53% of participants had any cognitive impairment (SPMSQ score = 1 or greater). They were more likely to be older, female, have less education and income, a greater number of comorbidities, and a higher severity of HF during the index admission compared with those with intact cognition.

A total of 23.8% (n = 210) of patients were readmitted within 30 days of discharge (Table 2). There was no statistically significant difference in readmission by numeracy level ($P = .66$). Readmitted patients were more likely to have lower objective health literacy compared with those who were not readmitted (27.1 vs 28.3; $P = .04$). A higher percentage of readmitted patients were cognitively impaired (57%) compared with those not readmitted (51%); however, this difference was not statistically significant ($P = .11$). Readmitted patients did not differ from nonreadmitted patients by demographic factors (supplementary Table 2). They were, however, more likely to have a history of HF, COPD, diabetes, CKD, higher Elixhauser scores, lower eGFR and lower sodium prior to discharge, and a greater number of prior readmissions in the last 12 months compared with those who were not readmitted (all $P < .05$).

In unadjusted and adjusted analyses, no statistically significant associations were seen between numeracy and the risk of 30-day readmission (Table 3). Additionally, in the adjusted analyses, there was no statistically significant association between objective health literacy or cognition and 30-day readmission. (supplementary Table 3). In a fully adjusted model, a history of diabetes was associated with a 30% greater risk of 30-day readmission compared with patients without a history of diabetes (RR = 1.30; $P = .04$) (supplementary Table 3). Per a 13-point increase in the Elixhauser score, the risk of readmission within 30 days increased by approximately 21% (RR = 1.21; $P = .02$). Additionally, having 3 prior hospital admissions in the previous 12 months was associated with a 30% higher risk of readmission than having 2 or fewer prior hospital admissions (RR = 1.3; $P < .001$).

DISCUSSION

This is the first study to examine the effect of numeracy alongside literacy and cognition on 30-day readmission risk among patients hospitalized with ADHF. Overall, we found that 33.9% of participants had inadequate numeracy skills, and 24.6% had inadequate or marginal health literacy. In unadjusted and adjusted models, numeracy was not associated with 30-day readmission. Although (objective) low health literacy was associated with 30-day readmission in unadjusted models, it was not in adjusted models. Additionally, though 53% of participants had any cognitive impairment, readmission did not differ significantly by this factor. Taken together, these findings suggest that other factors may be greater determinants of 30-day readmissions among patients hospitalized for ADHF.

Only 1 other study has examined the effect of numeracy on readmission risk among patients hospitalized for HF. In this multicenter prospective study, McNaughton et al.[37] found low numeracy to be associated with higher odds of recidivism to the emergency department (ED) or hospital within 30 days. Our findings may differ from theirs for a few reasons. First, their study had a significantly higher percentage of individuals with low numeracy (55%) compared with ours (33.9%). This may be because they did not exclude individuals with severe cognitive impairment, and their patient population was of lower socioeconomic status (SES) than ours. Low SES is associated with higher 30-day readmissions among HF patients[1,10] throughout the literature, and low numeracy is associated with low SES in other diseas-

TABLE 1. **Characteristics of Study Participants Hospitalized for Acute Decompensated Heart Failure (ADHF) by Subjective Numeracy, Objective Health Literacy, and Cognition in the Vanderbilt Inpatient Cohort Study (VICS)**

			Numeracy (n = 881)			Health Literacy (n = 825)			Cognition (n =878)		
			Inadequate	Adequate	*P* Value	Inadequate/ Marginal	Adequate	*P* Value	Any Impairment	Intact Cognition	*P* Value
Patient Characteristics	**N**	**Overall**	**n = 299**	**n = 582**		**n = 203**	**n = 622**		**n = 462**	**n = 416**	
Socio-Demographic Characteristics											
Age, median (IDR)	883	60 (39, 78)	63 (43, 81)	60 (38, 77)	<.001	63 (43, 81)	60 (38, 77)	<.001	61 (42, 80)	60 (38, 76)	.04
Female, n (%)	883	410 (46%)	104 (45%)	304 (47%)	.69	104 (45%)	304 (47%)	.69	239 (52%)	168 (40%)	<.001
Race:Non-White, n (%)	882	212 (24%)	44 (19%)	166 (26%)	.05	44 (19%)	166 (26%)	.05	126 (27%)	84 (20%)	.01
Education, median (IDR)	882	13 (11, 18)	12 (9, 14)	14 (12, 18)	<.001	12 (9, 14)	14 (12, 18)	<.001	12 (10, 16)	14 (12, 18)	<.001
Income, median (IDR)	839	5 (2, 8)	4 (2, 7)	5 (2, 8)	<.001	4 (2, 7)	5 (2, 8)	<.001	5 (1, 7)	6 (2, 9)	<.001
Home Status, n (%)	881				.18			.18			.08
Married		475 (54%)	136 (59%)	339 (52%)		136 (59%)	339 (52%)		233 (51%)	241 (58%)	
Not Married, Living with Someone		209 (24%)	50 (22%)	157 (24%)		50 (22%)	157 (24%)		120 (26%)	88 (21%)	
Not Married, Living Alone		197 (22%)	44 (19%)	153 (24%)		44 (19%)	153 (24%)		108 (23%)	87 (21%)	
Clinical and Diagnostic Characteristics											
History of HF, n (%)	864	688 (80%)	182 (81%)	503 (79%)	.57	182 (81%)	503 (79%)	.57	363 (80%)	320 (79%)	.73
History of COPD, n (%)	883	242 (27%)	78 (34%)	164 (25%)	.01	78 (34%)	164 (25%)	.011	144 (31%)	97 (23%)	.01
History of CAD, n (%)	863	375 (43%)	113 (50%)	262 (41%)	.02	113 (50%)	262 (41%)	.02	202 (44%)	171 (42%)	.52
History of Diabetes, n (%)	864	377 (44%)	114 (51%)	261 (41%)	.01	114 (51%)	261 (41%)	.01	210 (46%)	163 (40%)	.08
Depression, median (IDR)	865	9 (3, 17)	10 (4, 19)	8 (3, 16)	<.001	10 (4, 19)	8 (3, 16)	<.001	9 (3, 17)	8 (3, 16)	.43
Elixhauser Score, median (IDR)	867	20 (10, 34)	22 (12, 34)	21 (10, 35)	.11	21 (11, 33)	20 (9, 34)	.34	22 (11, 34)	20 (10, 35)	.09
Ejection Fraction (%), median (IDR)	868	40 (15, 60)	45 (15, 60)	38 (15, 60)	.05	45 (15, 60)	38 (15, 60)	.05	42 (15, 60)	35 (15, 60)	.08
EGFR, median (IQR)	865	57 (25, 97)	49 (23, 92)	60 (26, 97)	<.001	49 (23, 92)	60 (26, 97)	.001	57 (26, 97)	58 (25, 97)	.76
Hemoglobin (g/dL), median (IDR)	862	12 (9, 15)	11 (9, 15)	12 (9, 15)	.07	11 (9, 15)	12 (9, 15)	.07	11 (9, 15)	12 (9, 15)	.01
Sodium(mg/L), median (IDR)	865	137 (132, 141)	137 (132, 142)	137 (132, 141)	.81	137 (132, 142)	137 (132, 141)	.81	137 (133, 141)	137 (132, 141)	.6
BNP(pg/mL), median (IDR)	791	620 (110, 2374)	669 (107, 2502)	611 (116, 2242)	.59	669 (107, 2502)	611 (116, 2242)	.59	616 (114, 2505)	620 (106, 2219)	.48
Current smoker, n (%)	858	110 (13%)	17% (80/290)	11% (60/568)	<.001	38 (17%)	72 (11%)	.03	43 (15%)	67 (11%)	.06
Hospitalization Characteristics											
Length of Stay (days), median (IDR)	883	4 (2, 13)	5 (2, 11)	4 (2, 13)	.31	5 (2, 11)	4 (2, 13)	.31	5 (2, 13)	4 (2, 12)	.16
Transfer to ICU, n (%)	864	198 (23%)	47 (21%)	150 (24%)	.41	47 (21%)	150 (24%)	.41	106 (23%)	92 (23%)	.83
Number Admissions Past 12 Months	877	1 (0, 5)	2 (0, 5)	1 (0, 5)	.06	2 (0, 5)	1 (0, 5)	.06	2 (0, 5)	1 (0, 5)	.23

NOTE: Continuous variables are summarized with the median and interdecile range: median (IDR). Categorical variables are summarized with the n and percentage: n (%). N is the number of nonmissing values. Income was considered a continuous variable, but the numbers represent ordinal categories: 1 = <$10,000; 2 = $10,000 to $14,999; 3 = $15,000 to $19,999; 4 = $20,000 to $24,999; 5 = $25,000 to $34,999; 6 = $35,000 to $49,999; 7 = $50,000 to $74,999; 8 = $75,000 to $99,999; 9 = $100,00. Educational attainment ranges from 1 year to 25 years. For associations with categorical variables, the Pearson χ^2 test was used. For associations with continuous variables, the Kruskal-Wallis test was used. Abbreviations: ADHF, acute decompensated heart failure; BNP, brain natriuretic peptide; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; HF, heart failure; ICU, intensive care unit; IDR, interdecile range; IQR, interquartile range; VICS, Vanderbilt Inpatient Cohort Study.

es.[13,38,39] Finally, they studied recidivism, which was defined as any unplanned return to the ED or hospital within 30 days of the index ED visit for acute HF. We only focused on 30-day readmissions, which also may explain why our results differed.

We found that health literacy was not associated with 30-day readmissions, which is consistent with the literature. Although an association between health literacy and mortality exists among adults with HF, several studies have not found an association between health literacy and 30- and 90-day readmission among adults hospitalized for HF.[8,9,40] Although we found an association between objective health literacy and 30-day readmission in unadjusted analyses, we did not find one in the multivariable model. This, along with our numeracy finding, suggests that numeracy and literacy may not be driving the 30-day readmission risk among patients hospitalized with ADHF.

We examined cognition alongside numeracy and literacy because it is a prevalent condition among HF patients and because it is associated with adverse outcomes among patients with HF, including readmission.[41,42] Studies have shown that HF preferentially affects certain cognitive domains,[43] some of which are vital to HF self-care activities. We found that 53% of patients had any cognitive impairment, which is consistent with the literature of adults hospitalized for ADHF.[44,45] Cognitive impairment was not, however, associated with 30-day readmissions. There

may be a couple reasons for this. First, we measured cognitive impairment with the SPMSQ, which, although widely used and well-validated, does not assess executive function, the domain most commonly affected in HF patients with cognitive impairment.[46] Second, patients with severe cognitive impairment and those with delirium were excluded from this study, which may have limited our ability to detect differences in readmission by this factor.

As in prior studies, we found that a history of DM and more hospitalizations in the prior year were independently associated with 30-day readmissions in fully adjusted models. Like other studies, in adjusted models, we found that LVEF and a history of HF were not independently associated with 30-day readmission.[47-49] This, however, is not surprising because recent studies have shown that, although HF patients are at risk for multiple hospitalizations, early readmission after a hospitalization for ADHF specifically is often because of reasons unrelated to HF or a non-cardiovascular cause in general.[50,51]

Although a negative study, several important themes emerged. First, while we were able to assess numeracy, health literacy, and cognition, none of these measures were HF-specific. It is possible that we did not see an effect on readmission because our instruments failed to assess domains specific to HF, such as monitoring weight changes, following a low-salt diet, and interpreting blood pressure. Currently, however, no HF-specific objective numeracy measure exists. With respect to health literacy, only 1 HF-specific measure exists,[52] although it was only recently developed and validated. Second, while numeracy may not be a driving influence of all-cause 30-day readmissions, it may be associated with other health behaviors and quality metrics that we did not examine here, such as self-care, medication adherence, and HF-specific readmissions. Third, it is likely that the progression of HF itself, as well as the clinical management of patients following discharge, contribute significantly to 30-day readmissions. Increased attention to predischarge processes for HF patients occurred at VUMC during the study period; close follow-up and evidence-directed therapies may have mitigated some of the expected associations. Finally, we were not able to assess numeracy of participants' primary caregivers who may help patients at home, especially postdischarge. Though a number of studies have examined the role of family caregivers in the management of HF,[53,54] none have examined numeracy levels of caregivers in the context of HF, and this may be worth doing in future studies.

TABLE 2. **30-Day Readmissions by Numeracy, Health Literacy, and Cognition among Participants Hospitalized for ADHF in the VICS**

		Overall	No Readmission	Readmission	
	N	N = 883	N = 673	N = 210	*P* Value
Numeracy					
Numeracy category	881				.75
Inadequate		299 (34%)	230 (34%)	69 (33%)	
Adequate		582 (66%)	442 (66%)	140 (67%)	
Numeracy score	881	4 (2-6)	4 (2-6)	5 (2-6)	.66
Health literacy					
Subjective literacy category (BHLS)	880				.67
Inadequate		230 (26%)	178 (26%)	52 (25%)	
Adequate		650 (74%)	494 (74%)	156 (75%)	
BHLS	881	12 (7-15)	12 (7-15)	12 (6-15)	.52
Objective literacy category (sTOFHLA)	825				.11
Inadequate		127 (15%)	89 (14%)	38 (19%)	
Marginal		76 (9%)	63 (10%)	13 (7%)	
Adequate		622 (75%)	475 (76%)	147 (74%)	
sTOFHLA	825	32 (14-36)	33 (15-36)	31 (12-35)	.04
Cognition					
Cognition category	878				.11
Cognitive impairment		462 (53%)	342 (51%)	120 (57%)	
Intact cognition		416 (47%)	327 (49%)	89 (43%)	
Cognition score	878	0 (0-1)	0 (0-1)	0 (0-2)	.09

NOTE: N is the number of nonmissing values. For associations with categorical variables, the Pearson χ^2 test was used. For associations with continuous variables, the Wilcoxon test was used. Abbreviations: ADHF, acute decompensated heart failure; BHLS, Brief Health Literacy Screen; sTOFHLA, Short Test of Functional Health Literacy in Adults; VICS, Vanderbilt Inpatient Cohort Study.

Overall, our study has several strengths. The size of the cohort is large and there were high response rates during the follow-up period. Unlike other HF readmission studies, VICS accounts for readmissions to outside hospitals. Approximately 35% of all hospitalizations in VICS are to outside facilities. Thus, the ascertainment of readmissions to hospitals other than Vanderbilt is more comprehensive than if readmissions to VUMC were only considered. We were able to include a number of clinical comorbidities, laboratory and diagnostic tests from the index admission, and hospitalization characteristics in our analyses. Finally, we performed additional analyses to investigate the correlation between numeracy, literacy, and cognition; ultimately, we found that the majority of these correlations were weak, which supports our ability to study them simultaneously among VICS participants.

Nonetheless, we note some limitations. Although we cap-

TABLE 3. **The Effect of Numeracy on 30-Day Readmissions among Those Hospitalized for ADHF in the VICS**

	Model 1			Model 2			Model 3			Model 4			Model 5		
Numeracy	**RR**	**95% CI**	***P* Value**	**RR**	**95% CI**	***P* Value**	**RR**	**95% CI**	***P* Value**	**RR**	**95% CI**	***P* Value**	**RR**	**95% CI**	***P* Value**
Numeracy score (per 2 point change)	1.02	0.86-1.23	.79	1.09	0.89-1.33	.39	1.04	0.83-1.29	.75	1.06	0.85-1.33	.57	1.04	0.83-1.30	.72

NOTE: Poisson Model Estimates: Model 1 adjusts for numeracy alone; Model 2 adjusts for the Model 1 variable and adjusts for health literacy and cognition; Model 3 adjusts for the Model 2 variables and demographics; Model 4 adjusts for Model 3 variables and clinical and diagnostic characteristics; and Model 5 adjusts for Model 4 variables and hospitalization characteristics.
Abbreviations: ADHF, acute decompensated heart failure; CI, confidence interval; RR, risk ratio; VICS, Vanderbilt Inpatient Cohort Study.

tured readmissions to outside hospitals, the study took place at a single referral center in Tennessee. Though patients were diverse in age and comorbidities, they were mostly white and of higher SES. Finally, we used home status as a proxy for social support, which may underestimate the support that home care workers provide.

In conclusion, in this prospective longitudinal study of adults hospitalized with ADHF, inadequate numeracy was present in more than a third of patients, and low health literacy was present in roughly a quarter of patients. Neither numeracy nor health literacy, however, were associated with 30-day readmissions in adjusted analyses. Any cognitive impairment, although present in roughly one-half of patients, was not associated with 30-day readmission either. Our findings suggest that other influences may play a more dominant role in determining 30-day readmission rates in patients hospitalized for ADHF than inadequate numeracy, low health literacy, or cognitive impairment as assessed here.

Acknowledgments

This research was supported by the National Heart, Lung, and Blood Institute (R01 HL109388) and in part by the National Center for Advancing Translational Sciences (UL1 TR000445-06). The content is solely the responsibility of the authors and does not necessarily represent official views of the National Institutes of Health. The authors' funding sources did not participate in the planning, collection, analysis, or interpretation of data or in the decision to submit for publication. Dr. Sterling is supported by T32HS000066 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality. Dr. Mixon has a VA Health Services Research and Development Service Career Development Award at the Tennessee Valley Healthcare System, Department of Veterans Affairs (CDA 12-168). This material was presented at the Society of General Internal Medicine Annual Meeting on April 20, 2017, in Washington, DC.

Disclosure: Dr. Kripalani reports personal fees from Verustat, personal fees from SAI Interactive, and equity from Bioscape Digital, all outside of the submitted work. Dr. Rothman and Dr. Wallston report personal fees from EdLogics outside of the submitted work. All of the other authors have nothing to disclose.

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