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Cognitive Function and Health Literacy are Independently Associated with Heart Failure Knowledge

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Abstract

Objectives—Determine the relationship between cognitive function and health literacy in heart failure (HF) knowledge in a sample of patients with HF.

Background—HF is a disease requiring an extensive treatment regimen; thus, cognition and health literacy may contribute to understanding and self-management of HF.

Methods—Participants were 330 HF outpatients. Health literacy was assessed using the Medical Term Recognition Test and the Rapid Estimate of Adult Literacy in Medicine. Global cognitive function was screened with the Modified Mini-Mental Status Examination. HF knowledge was assessed with the Dutch Heart Failure Knowledge Scale (DHFKS).

Results—Health literacy ($\beta=.26, p<.001$) and cognition ($\beta=.36, p<.001$) were related to DHFKS after adjusting for covariates. Both scores were independently associated with DHFKS (health literacy: $\beta=.13, p=.044$ and cognition: $\beta=.30, p<.001$).

Conclusions—Impairments in health literacy and cognition were independently associated with reduced HF knowledge. Interventions should address both factors in order to be maximally effective.

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Keywords

health literacy; heart failure; knowledge; cognitive function; neuropsychological testing

Introduction

An estimated 5.1 million individuals in the United States¹ are diagnosed with heart failure (HF). These individuals typically have high rates of physician visits and hospitalizations, and half will die within 5 years of diagnosis.¹ With such adverse patient impact, HF has become one of the most financially burdensome diseases in the nation with \$32 billion in expenditures annually.¹ These personal and societal costs highlight the need for optimizing HF treatments and patients' adherence to these interventions via effective patient education, counseling, and communication. At the same time, HF treatment regimens are complex and require substantial health literacy, which is defined as the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.² While the evidence on health literacy in the HF population is relatively sparse, there is preliminary evidence to show that low health literacy may compromise effective self-management and successful HF treatment, and, ultimately, result in poor HF outcomes.

Indeed, low health literacy predicts multiple undesirable outcomes in patients with HF^{3,4}. Murray et al.³ found that adequate health literacy is associated with lower risk of HF hospitalizations after controlling for clinical factors, and ability to read and comprehend medical information was more strongly related to HF exacerbation than conventional biological prognostic indicators, such as ejection fraction.³ Similarly, Peterson et al. (2011) reported that low health literacy is associated with higher all-cause mortality among patients with HF.⁴ These findings parallel the larger body of literature documenting the association between low health literacy and poorer health outcomes across a variety of medical conditions.⁵ Together, such results recently encouraged a consensus statement from the Heart Failure Society of America which called for the "timely recognition of low health literacy combined with tailored interventions" (p. 2) in patients with HF.⁶ Given that up to 73% of patients with HF may have low health literacy,⁷ it is important to further explore how impaired health literacy contributes to poor patient outcomes in order to better design and tailor effective interventions.

One potential mechanistic pathway that has been proposed is that impaired health literacy impedes the encoding or retention of knowledge needed for effective HF self-care.⁸ Consequently, individuals with inadequate health literacy may have less knowledge about their disease⁹ and its management, and thus may be less likely to adhere to treatment recommendations.¹⁰ Thus, finding alternate methods for acquiring HF knowledge in those with inadequate health literacy is likely to be an important target for patient education and/or counseling interventions.

Importantly, HF-related cognitive deficits have been found in up to 80% of patients^{11,12} and may lead to impaired self-care, greater disability, and increased mortality.^{13,14} These deficits arise from the HF disease process, including reduced cardiac output, low systolic blood

pressure, endothelial dysfunction, and autoregulatory and rheological abnormalities, all of which can contribute to a primary determinant of cognitive deficits: reduced cerebral blood flow.^{15,16} Furthermore, cognitive abilities explain a substantial proportion of the variance in health literacy levels^{17,18} and thus may be partly responsible for the relationship between health literacy and HF knowledge. The conceptual model for how cognitive deficits and low health literacy may act together to contribute to adverse HF failure outcomes by preventing learning or uptake of knowledge about the disease and therefore its management are presented in Figure 1. As a specific example of this model in action, deficits in memory may impede a patient's ability to remember basic information about the clinical importance of daily weighing in HF (low literacy) [predictors]; thus, he lacks knowledge of when to weigh and what constitutes a clinically significant weight gain [mechanism], which leads to failure to call a health care professional after a significant weight gain [behavioral outcome] and consequent exacerbation of fluid retention [health outcome]. To our knowledge, no studies to date have examined whether low health literacy acts independently of HF-related cognitive deficits to predict low HF knowledge in this population or whether one factor is a stronger predictor of knowledge than the other. Accordingly, the objective of this study was to examine whether health literacy and cognitive function are uniquely associated with HF knowledge.

Methods

Study Design

The Heart Failure Adherence, Behavior, and Cognition Study (Heart ABC)¹⁹ is a prospective observational cohort study of community-dwelling patients with HF. Heart ABC patients were recruited from two separate healthcare systems in northeast Ohio. Patients with a documented diagnosis of systolic HF were recruited from cardiac inpatient units and outpatient practices. The broad aims of the parent Heart ABC study were to examine cognitive function, psychosocial, and physical factors as predictors of adherence in patients with HF. Other reports from this study have been published examining cognitive screening methods in HF²⁰ and the relationship between cognition and other variables (e.g., body mass index,²¹ depression,²² quality of life,²³ and adherence behaviors²⁴).

Participants

A total of 372 participants were enrolled in the parent study using the following criteria. Inclusion criteria were: (1) Aged 50–85 years at enrollment, (2) Documented systolic HF diagnosis (ejection fraction; EF < 40%) within 36 months of enrollment, (3) physician-documented New York Heart Association (NYHA) class II or III for 3 months at the time of study enrollment, (4) No cardiac surgery in the previous 3 months, (5) No history of neurological disorder/injury (e.g., Alzheimer's disease, stroke), (6) No history of moderate or severe head injury, (7) No past or current history of psychotic disorders, bipolar disorder, learning disorder, developmental disability, renal failure requiring dialysis, or untreated sleep apnea, (8) No substance abuse currently or within the past 5 years, and (9) No current participation in home tele-health monitoring program for HF, and (10) Native English speaker. From the larger sample, we selected participants with complete data on the key

variables (health literacy, cognitive function, and HF knowledge), yielding a final sample of 330 persons with HF for analysis.

Variables and Measures

Health Literacy—Health literacy was assessed using the Medical Term Recognition Test²⁵ and the Rapid Estimate of Adult Literacy in Medicine.²⁶ For the Medical Term Recognition Test, participants are given a list of 70 words, 40 of which are actual medical terms (e.g., “appendix”), and 30 which are non-words (e.g., “abghorral”). Participants are asked to identify which are real words. A raw score is calculated as the sum of real words correctly identified (possible range: 0–40) with scores ≥ 35 indicative of functional literacy. Reported internal consistency for this test is high (Cronbach’s $\alpha = 0.93$) with adequate sensitivity and specificity (75% correct identification and 8% false positives).²⁵ For the Rapid Estimate of Adult Literacy in Medicine, participants are instructed to read aloud a list of 66 medical words. A raw score is calculated as the sum of the words pronounced correctly (possible range: 0–66) with scores ≥ 61 indicative of functional literacy. This test also has strong internal consistency (Cronbach’s $\alpha = 0.96$)²⁷ and is considered a gold standard and most commonly used measure of literacy.²⁸ The scores from each measure were strongly correlated ($r = .82$); thus, scores for each test were converted to z-scores and averaged to form a composite health literacy z-score. Higher z-scores indicate better health literacy.

Global Cognition—Global cognitive function was screened with the Modified Mini-Mental Status Examination (3MS).²⁹ The 3MS is comprised of a series of short tasks assess various cognitive dimensions including orientation, learning and recall of words, copy of a simple geometric figure, delayed word recall, animal fluency, and executive function. The 3MS has better validity, reliability (Cronbach’s $\alpha = 0.88$), and sensitivity (.93) than the MMSE.²⁹ Higher scores indicate better global cognitive function (possible range: 0–100). We employed a continuous measure of cognitive function in our data analyses to promote greater response variability.

Heart Failure Knowledge—HF knowledge was assessed with the Dutch Heart Failure Knowledge Scale (DHFKS).³⁰ The DHFKS consists of 15 items assessing general HF knowledge, symptom recognition, and treatment knowledge. Higher scores reflect greater HF knowledge (possible range: 0–15). The DHFKS is valid and reliable.³⁰ We also assessed free recall of HF knowledge with a 5-item scale created for the study. Specifically, participants were asked: (1) the maximum amount of salt that should be consumed in a day, (2) to give examples of foods that contain a lot of salt, (3) how often they should be weighing themselves, (4) when they should call a health care provider regarding weight, and (5) to list other HF symptoms that would warrant calling a provider. Given that the free recall scale is not a validated scale and the internal consistency of the five items was .46, it was used for descriptive purposes only and not for the primary analyses. Of note, the knowledge questionnaires were administered to assess current baseline knowledge, regardless of any prior inpatient or outpatient education interventions received (not assessed). After the assessment, all participants were given a HF self-management educational brochure and any knowledge deficits were addressed in order to ensure that all

participants had received the same standardized educational materials and information for their remaining time in the study.

Covariates—The following variables were included as covariates/potential confounders of any observed relationship between health literacy, cognitive function, and HF knowledge: age (years), race (0 = white, 1 = non-white), education (1 = 8th grade or less, 2 = 9–11th grade, 3 = high school, 4 = technical or trade school, 5 = some college, 6 = bachelor's degree, 7 = master's degree), socioeconomic status (SES), Charlson Comorbidity Index (CCI) score,³¹ and HF severity (as estimated by the four levels of the NYHA.³² SES was estimated using zip code via a method similar to the one described by Roux et al.³³ Z-scores were calculated for the SES score using indicators of income and education for each zip code. Higher scores indicate higher socioeconomic status. The CCI is a summary score of several medical conditions which are deemed to increase mortality.³¹ The NYHA HF severity levels³² are as follows: Class I (Mild), Class II – (Mild), Class III (Moderate), and Class IV (Severe). Baseline self-reported and subjective experience of heart failure functional severity was assessed by asking participants' questions about their current symptoms (e.g., “*Do you markedly reduce physical activity due to shortness of breath?*”). Based on their subjective and self-reported responses, we assigned them to the corresponding NYHA functional classes. Thus, at the baseline assessment, some patients' HF were categorized as class I or IV based on their current self-reported and subjectively-experienced functional level despite the initial inclusion criteria of physician-documented NYHA class II or III at the time of enrollment.

Procedure

All patients gave written, informed consent to participate. This investigation conforms with the principles outlined in the Declaration of Helsinki, and the Institutional Review Boards of Kent State University, Summa Health Systems, Inc., and Case Western Reserve University approved all study procedures. After recruitment and consent, a research assistant administered a series of questionnaires and the standardized cognitive screening measure.

Data Analysis

Data were cleaned and examined for normality assumptions. All variables were within range (e.g. skew < |3.0|, kurtosis < 10.0) and, thus, were not transformed.³⁴ Missing data was not imputed. We computed descriptive statistics to describe the proportion of the sample with impaired literacy and cognitive function scores as well as the proportion of the sample that correctly answered the free recall knowledge questions. To examine the relationship between health literacy and cognitive function, a series of linear regressions was conducted. Specifically, we ran both independent and simultaneous models. Each model analysis was performed with the DHFKS score as the dependent variable. First, the main effects of health literacy and cognitive function were examined in independent (separate) 1 models by entering age, sex, race, education, SES, CCI, and HF severity on Step 1 and *either* the health literacy or 3MS score in Step 2. Next, we ran a simultaneous model with the health literacy and 3MS score entered together in Step 2 to determine whether the scores had independent or unique effects on the DHFKS score. All analyses were conducted using IBM® SPSS® version 20.0 statistical software (IBM Corporation).

Results

Participants

Descriptive data were analyzed for 330 participants (see Table 1). Participants were mostly male (60.6%), white (72.1%), had more than a high school degree (60.9%), and were an average age of 68.45 years. Using the cut-off scores for functional literacy, 25.2% ($n = 83$) of participants had impaired literacy on the Medical Term Recognition Test and 27.9% ($n = 92$) on the Rapid Estimate of Adult Literacy in Medicine. With regard to cognitive impairment, 34.5% ($n = 114$) of participants had impaired performance on the 3MS. Of the 114 individuals with cognitive impairment, 49.1% ($n = 56$) had impaired literacy on the Medical Term Recognition Test and 52.6% ($n = 60$) had impaired literacy on the Rapid Estimate of Adult Literacy in Medicine. Of the individuals with impaired health literacy on the Medical Term Recognition Test or Rapid Estimate of Adult Literacy in Medicine, 67.5% ($n = 56$) and 65.2% ($n = 60$) had impaired cognitive function, respectively.

Free Recall of Heart Failure Knowledge

The free recall questions demonstrated that participants had varying levels of knowledge related to common HF treatment recommendations (see Figure 1). For example, most participants (88.5%) could name foods that are high in salt, but only 22.6% knew how much salt should be consumed in a day. A small majority (64.55%) knew they should be weighing themselves daily, but just over 35% knew when to call a health care professional regarding weight gain.

Main Effects of Health Literacy and Cognitive Function on HF Knowledge

Linear regressions testing the main effects of health literacy and cognition on HF knowledge in separate models revealed that both the health literacy ($\beta = .26, p < .001$) and the 3MS ($\beta = .36, p < .001$) score were related to the DHFKS score after adjustment for covariates (See Table 2). The covariates accounted for 11.4% of the variance in DHFKS, whereas the health literacy and the cognition scores accounted for an additional 5.1% and 10.0% of the variance, respectively, when entered separately into the models.

When entered simultaneously into the model, both scores remained associated with the DHFKS score (health literacy: $\beta = .13, p = .044$ and cognition: ($\beta = .30, p < .001$) and together accounted for an additional 11.0% of variance over and above the covariates. These results indicate that health literacy and cognitive function have independent effects on HF knowledge but that cognitive function accounted for more variance in HF knowledge and reduced the impact of health literacy, suggesting partial mediation. The addition of cognition reduced the effects of health literacy on HF knowledge by nearly 50% ($\beta = .26$ vs. $\beta = .13$), whereas the addition of the health literacy score reduced the effect of the cognition by 17% ($\beta = .36$ vs. $\beta = .30$).

Discussion

Main effects of health literacy and cognitive function on HF knowledge were observed even after controlling for demographic, socioeconomic, and medical factors. Importantly, both

impaired health literacy and poorer cognitive function were uniquely associated with less HF knowledge, although the effect of cognitive function was twice as large as the health literacy effect (10% vs. 5% variance accounted for) and accounted for 50% of the effect of health literacy. In contrast, health literacy accounted for less than 20% of the effect of cognition. This pattern of results suggests that both factors are unique predictors of HF knowledge and that they may impact one another as well (see Figure 1 for conceptual model).

Overall, 25–30% of the sample had impaired health literacy, whereas 35% exhibited cognitive impairment. Of those with cognitive impairment, 49–53% had impaired health literacy, whereas 65–68% of individuals with impaired health literacy had cognitive impairment. The respective rates of impairment in health literacy and cognitive function in our sample were somewhat lower than the 39–73%⁷ and 53–58%¹² reported in previous studies. However, the prevalence of impairment in our sample was still very high – with one in four individuals lacking functional health literacy and over one-third exhibiting cognitive impairment. In addition, our finding that impaired health literacy was associated with poorer HF knowledge is directly supported by evidence that low health literacy is associated with poorer general⁷ and sodium knowledge in HF patients.³⁵

We extend past findings by demonstrating that health literacy does have a small impact on HF knowledge, independent of cognitive impairment. Our results are consistent with those of Wolf et al.³⁶ that showed the addition of cognitive abilities into models with health literacy attenuated the effects of health literacy by 71–78%, although both were still significant predictors of performance on health tasks. Though Wolf and colleagues did not examine a HF population or use HF knowledge as the outcome variable, together with our study, the findings highlight the need for examining the respective roles of low health literacy and cognitive function in HF outcomes and emphasize the large impact of cognitive abilities on HF knowledge.

The stronger relationship detected between cognitive function and HF knowledge compared with the relationship between health literacy and HF knowledge suggests that the cognitive status of patients should be addressed in order for low literacy interventions to be maximally effective. As an example, in their initial pilot disease management program targeting low literacy patients with HF, DeWalt et al.³⁷ found that, although patient accuracy in following the treatment protocol improved, 33% of patients still had errors in self-management and no improvement in HF knowledge scores was observed. One reason for the high error rate and the lack of improvement in knowledge may be that patients' cognitive impairment was not addressed by the intervention.

Suggestions that low literacy interventions will only be maximally effective if they reduce demands on cognitive abilities^{17,18} have been taken seriously as more recent HF interventions have begun to address both low literacy and cognitive deficits.³⁸ Such interventions attempt to present health information at lower reading levels and/or with graphics to address low literacy but also try to reduce working memory load, allow for slower processing speeds, and employ the use of memory prompts and external aids (e.g., medication reminders or pill boxes) in order to account for cognitive deficits as well.^{36,38} Other interventions which have focused primarily on cognitive deficits in HF have yielded

more promising improvements in HF knowledge, but these improvements were not associated with better self-care or reduced readmission rates.³⁹ In another study, investigators found that cognitive function was not a significant predictor of self-care in patient with HF⁴⁰ despite contradictory evidence that cognitive impairment is implicated in impaired self-care,⁴¹ greater disability,¹³ and increased mortality¹⁴ in patients with HF. It is clear from the discrepancies across studies that future investigations are needed to clarify how health literacy, cognitive function, and HF knowledge contribute to self-management and HF outcomes. Interventions that effectively target low health literacy and cognitive function should not only address these factors but also demonstrate impact on adverse HF outcomes, such as inadequate self-care behaviors, treatment nonadherence, rehospitalization, and mortality rates. Such information will be helpful in determining the downstream effects of increasing HF knowledge, given that knowledge is likely necessary but not sufficient for self-care or self-management behavior. Accordingly, even though HF knowledge may be improved by interventions for low health literacy and cognitive deficits, additional intervention may be needed before knowledge is translated into optimal self-management behaviors. Such interventions may include patient empowerment approaches,⁴² motivational counseling/interviewing for behavior change,^{43,44} and/or eliciting family caregivers support in home HF management.⁴⁵ Future research should test these assumptions but the implications of our study are that multi-faceted interventional approach will be necessary, one that addresses low literacy, cognitive deficits, and reduced HF knowledge for patients with a complex and treatment-intensive disease.

The current findings are limited in several ways. First, the cross-sectional design precludes our ability to determine the directional relationships between health literacy, cognitive abilities, and HF knowledge over time in a HF population. Future research should examine the direction of the relationships by using longitudinal methodology. Second, future analyses could utilize a battery of cognitive measures to clarify the role of specific cognitive domains rather than using a single mental status exam as a screening tool for cognitive impairment. Next, the role of medication use and adherence will be likely be bi-directionally related to cognitive function and their role should be explored in future studies. Finally, we did not have the opportunity to determine whether the impairments in health literacy or cognitive function led to reduced function in activities of daily living (ADLs). Past work has shown high rates of disability in HF,¹³ and it is necessary to determine whether low health literacy, cognitive impairment, and less HF knowledge impair daily functioning.

Conclusions and Practical Implications

In brief conclusion, the current findings suggest that impaired healthy literacy and poorer cognitive function are independently associated with less HF knowledge in a sample of patients with HF. Future studies should further clarify not only the interconnections between literacy, cognition, and knowledge but also the impact of these factors on adverse HF outcomes (e.g., ADLs, rehospitalization rates). The finding that both health literacy and cognitive function are unique predictors of HF knowledge suggests that both factors should be addressed in patient education interventions designed to improve HF knowledge. Given that cognitive function exerted a stronger influence on HF knowledge than did health

literacy, low literacy interventions may only be maximally effective if they reduce demands on patients' cognitive abilities.

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Abbreviations

3MS	Modified Mini-Mental Status Examination
DHFKS	Dutch Heart Failure Knowledge Scale
HF	heart failure

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Highlights

1. Cognition and health literacy uniquely impact patient knowledge
2. Effects of cognition on HF knowledge are stronger
3. HF literacy interventions may need to address cognition

Other contributing factors may include but are not limited to: socioeconomic status, education level, disease severity comorbidity status, social support, depression, treatment regimen complexity, access to providers.

Figure 1.
Model of Cognitive Function and Health Literacy as Interrelated Predictors of Heart Failure Outcomes via Heart Failure Knowledge

Figure 2.

Percentage of patients with correct responses to a free recall questionnaire of heart failure treatment recommendation guidelines regarding sodium restriction, self-weighing, and contact with the health care professional.

Table 1**Characteristics of Participants (*N* = 330)**

	<i>M(SD) or N(%)</i>
<i>Demographic and Medical Factors</i>	
Age	68.45(9.48)
Female	130(39.39)
Minority Status ^a	92(27.88)
Education Level	
8 th Grade or Less	7(2.12)
9–11 th Grade	29(8.79)
High School	93(28.18)
Technical or Trade School	36(10.91)
Some College	91(27.58)
Bachelor's Degree	42(12.73)
Master's Degree	32(9.70)
Living Arrangements	
Alone	78(23.6)
With Spouse	184(55.8)
With Family Member (permanently)	50(15.2)
With Family Member (temporarily)	8(2.4)
With Friend (permanently)	7(2.1)
With Friend (temporarily)	3(0.9)
SES <i>z</i> -score	0.09(4.31)
Charlson Comorbidity Index	3.30(1.75)
Self-reported, subjective NYHA functional level at baseline data collection ^b	
Class I	33 (10.0)
Class II	76 (23.0)
Class III	202 (61.2)
Class IV	19 (5.8)
<i>Health Literacy, Cognition, and Knowledge Factors (Possible Range)</i>	
METER Score (0–40)	35.38(5.99)
REALM Score (0–66)	60.69(9.18)
Global Cognitive Function (0–100)	91.99(6.66)
Dutch HF Knowledge Scale (0–15)	11.54(1.89)

Note. SES = socioeconomic status. NYHA = New York Heart Association. METER = Medical Term Recognition Test. REALM = Rapid Estimate of Adult Literacy in Medicine. HF = heart failure. Means and standard deviations are presented for continuous variables. Sample size and percentages are presented for categorical variables.

^aDetails for minority status: 96% African American (*N* = 88), 3% American Indian (*N* = 3), and 1% Asian/Pacific Islander (*N* = 1).

^bAt the time of recruitment, only participants reporting a NYHA cardiac functional classification II or III were enrolled. The data reported in this table reflect the participants self-reported status at the first data collection.

Table 2

Regression Results of Main Effects of Health Literacy and Cognitive Function on Heart Failure Knowledge

	Step 1 ^a	Model 1 Step 2: ^b Independent Entry Health Literacy	Model 2 Step 2: ^b Independent Entry Cognitive Function	Model 3 Step 2: ^b Simultaneous Entry
Total % Variance Accounted for; R ² (R ²)	11.4%	16.5% (+5.1%)	21.4% (+10.0%)	22.4% (+11.0%)
Age	-.07	-.08	.01	-.00
Sex	.22 **	.16 *	.17 *	.15 *
Race/ethnicity	-.14 *	-.07	-.07	-.04
Education	.25 **	.17 *	.14 *	.12 *
SES	.02	.00	-.02	-.02
Charlson Comorbidity	-.03	-.04	-.04	-.05
HF Severity	.04	.05	.05	.06
Health Literacy Composite	--	.26 **	--	.13 *
Global Cognitive Function (3MS)	--	--	.36 **	.30 **

Note. SES = socioeconomic status. 3MS = Modified Mental State Examination

^aStep 1 is presented only once for all three models because results are equivalent across models prior to entry of additional variables on Step 2.

^b Each Step 2 is from a separate model in which either the Health Literacy Composite, the Global Cognitive Function, OR both were entered on Step 2. Beta coefficients for covariates are updated accordingly.

* Significant at p<.05,

** Significant at p<.01