Clinical Epidemiology

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ORIGINAL RESEARCH

Cognitive impairment and self-care in heart failure

This article was published in the following Dove Press journal:
Clinical Epidemiology
16 October 2013
Number of times this article has been viewed

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Background: Heart failure (HF) is a prevalent chronic disease in older adults that requires extensive self-care to prevent decompensation and hospitalization. Cognitive impairment may impact the ability to perform HF self-care activities. We examined the association between cognitive impairment and adherence to self-care in patients hospitalized for acute HF.

Design: Prospective cohort study.

Setting and participants: A total of 577 patients (mean age = 71 years, 44% female) hospitalized for HF at five medical centers in the United States and Canada.

Measurements and methods: Participants were interviewed for information on self-reported adherence to self-care using the European Heart Failure Self-care Behaviour Scale. We assessed cognitive impairment in three domains (memory, processing speed, and executive function) using standardized measures. Patients' demographic and clinical characteristics were obtained through medical record review. Multivariable linear regression was used to examine the association between cognitive impairment and self-care practices adjusting for demographic and clinical factors.

Results: A total of 453 patients (79%) were impaired in at least one cognitive domain. Average adherence to self-care activities among patients with global cognitive impairment did not differ significantly from those without cognitive impairment (30.5 versus 29.6; 45-point scale). However, impaired memory was associated with lower self-care scores ($P = 0.006$) in multivariable models.

Conclusion: Cognitive impairment is highly prevalent among older patients hospitalized for HF. Memory impairment is associated with poorer adherence to self-care practices. Screening for memory impairment in patients with HF may help to identify patients at risk for poor self-care who may benefit from tailored disease management programs.

Keywords: heart failure, cognition, self-care

Introduction

Heart failure (HF) is a chronic, progressive disease affecting approximately six million Americans, mostly older adults, and is often characterized by frequent hospitalizations.[1] Effective outpatient management of HF requires extensive patient self-care to control symptoms and prevent hospitalization.[2–5] Self-care in HF is a complex process characterized by engagement in secondary preventive practices (eg, salt and fluid restrictions, weighing oneself daily, adhering to prescribed medications), management of symptoms (eg, resting when feeling short of breath), and making decisions about the need for medical care (eg, seeking medical help when symptoms occur).[3,6]

Importantly, up to 50% of hospitalizations for HF can be prevented with optimal self-care.[7,8] Despite the importance of effective self-care, many patients do not adhere

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to preventive lifestyle practices (eg, dietary restrictions or medication adherence), symptom monitoring, and care-seeking for acute decompensation.[4,9] Inadequate self-care increases a patient's risk for hospitalization and poor clinical and quality of life outcomes.[10]

Several factors have been examined as predictors of adherence to self-care regimens in patients with HF. Longer duration of disease, higher general health knowledge, and better health literacy are associated with better self-care, while male gender, comorbidity burden, depression, and low self-efficacy have been associated with poorer adherence to self-care.[2,3,9–14] However, self-care education programs, even those tailored to factors known to be associated with self-care, have met with limited success.[5,15] For example, a randomized clinical trial[5] assessing the impact of computer-based patient education about self-management in HF found significant improvements in HF-related knowledge but no improvements in self-care over time, suggesting that factors other than a knowledge deficit must be sought for differences in self-care among patients with HF.

Cognitive impairment is an important clinical factor that is present in up to three-quarters of older patients seeking care for HF and is associated with an increased risk of rehospitalization and mortality.[16–21] Cognitive impairment may influence outcomes in persons with HF by impacting a patient's abilities to engage in effective self-care. Indeed, cognitive impairment has been associated with reduced adherence to therapeutic recommendations and poorer self-care practices in patients with other chronic diseases such as diabetes and hypertension.[22,23]

Cognitive impairment may affect older patients' abilities to adequately perform self-care activities in a number of ways. Deficits in memory and attention may impair the ability to learn and remember information needed to perform preventive behaviors,[24] while symptom perception, evaluation, and treatment-seeking may be inhibited in individuals with impaired processing speed and executive function.[25] A recent study found that HF patients with cognitive impairment had decreased ability to carry out essential self-care activities; however, this study included fewer than 100 patients and did not examine impairment in specific cognitive domains in relation to self-care.[26]

The objective of the present study was to examine the association between impairment in three cognitive domains frequently impaired in HF (memory, processing speed, and executive function) and adherence to self-care among 577 older patients hospitalized with decompensated HF. We hypothesized that patients with cognitive impairment would have poorer self-care than cognitively intact patients.

Methods

Data for this study were derived from an ancillary study to the Observational Study of Delay in Heart Failure, a prospective cohort study that evaluated the extent of, and factors associated with, delays in hospital presentation among patients with acute HF. Our ancillary study added measures of cognition and self-care and included 894 patients hospitalized for acute HF between July 2007 and April 2011 at five urban medical centers in Worcester, Massachusetts, Providence, Rhode Island, USA, and Hamilton, Ontario, Canada. The study was approved by the institutional review boards at all study sites.

Details of the study have been previously described.[27] Nurse and physician interviewers conducted daily reviews of computerized hospital admission data for patients with an admission diagnosis of possible HF (International Classification of Disease-9 code 428). Patients admitted with less specific diagnoses (eg, dyspnea) or other diagnoses in which HF is possible (eg, pneumonia) were also screened for possible study inclusion. The interviewers performed a preliminary review of the medical record shortly after admission as well as immediately before approaching a patient for interview to determine whether the patient satisfied the Framingham criteria for HF.[28] The Framingham criteria for HF require the presence of two major criteria (eg, S3 gallop, increased venous pressure [>16 cm H_20]), or one major and two minor criteria (eg, extremity edema, dyspnea on exertion).[28] These well accepted criteria have been shown to be 100% sensitive and 78% specific in identifying patients with definite HF[29] and have been used extensively to validate HF diagnoses in large epidemiologic studies.[30] Patients whose HF occurred in the context of a myocardial infarction, those who developed HF secondary to an iatrogenic volume loading/blood transfusion or interventional procedure (eg, coronary artery bypass surgery), or who developed HF secondary to admission for another acute illness were excluded.

Eligible patients were approached by trained interviewers within 72 hours of hospital admission (mean = 1.8 (±0.9) days). The interviewers described the study, assessed the patient's ability to provide informed consent, and screened patients for delirium using the Confusion Assessment Method (CAM).[31] Patients who screened positive for delirium based on the CAM were excluded. Eligible patients were consented and underwent an in-depth, 45-minute standardized interview consisting of history of chief complaint(s) and ancillary presenting symptoms as well as assessments of cognitive function and

adherence to HF-related self-care activities. After the interview, additional information was collected from hospital charts about each patient's medical history (eg, diabetes, stroke) and relevant clinical information (eg, in-hospital complications and treatments) by trained study nurses and physicians on whom regular quality control checks were performed.

Assessment of cognitive function

Patients' cognition in the domains of memory, executive function, and processing speed (known to be affected in patients with HF[32]) was assessed using standardized measures by trained interviewers while patients were hospitalized for acute decompensation of HF. Specifically, we administered tests of delayed memory, digit-symbol coding (speed of processing), and verbal fluency (executive function), which have shown evidence of being sensitive to mild cognitive impairment[33] and were recommended by the National Institute of Neurological Disorders and Stroke (NINDS) as a bedside tool for identifying cognitive impairment associated with cardiovascular disease.[34] Delayed memory was assessed using the five-word immediate and delayed memory test, a subscale of the Montreal Cognitive Assessment Battery (MoCA; www.mocatest.org); a score of ≤2 was used to indicate impairment based on the MoCA scoring guidelines.[33] A modified Controlled Oral Word Association Test (COWA)[35] in which participants were asked to call out as many words as they could that start with the letter "f" in 60 seconds was administered to assess executive function. The total words called out by the patient during the 60-second period were counted and patients were classified as impaired in executive function if they generated fewer than 11, in accordance with the MoCA scoring algorithm. The Digit Symbol Substitution Test,[36] which asks participants to transcribe a number code into a symbol code using a given number/symbol key as quickly as possible for 90 seconds, was administered to measure processing speed and attention; a total of less than 27 consecutive correct responses signaled impairment.[37] Cognitive impairment was examined in two ways in this study: (1) impairment in any ability, and (2) impairment in specific domains of cognitive function, to determine whether certain cognitive domains were more or less associated with adherence to self-care activities. Patients who did not screen positive for cognitive impairment(s) were used as the comparison group in all analyses.

Assessment of self-care in HF

Participants' engagement in HF self-care activities was measured during the in-hospital interview using the 9-item European Heart Failure Self-care Behaviour Scale (EHFScBS-9)[6]. This is a self-administered validated questionnaire that includes nine items related to diet, medication adherence, symptom monitoring and recognition, and care-seeking behavior in HF that are answered on a five-point scale ranging from "Completely Agree" to "Completely Disagree." Scores on the EHFScBS-9 range from 9 to 45, with lower scores indicating better self-care. For ease of interpretation, scores were reversed in this study so that higher scores reflected better self-care.

Data analysis

Participants with complete data on cognitive impairment and self-care were included in the final study sample. Demographic and clinical characteristics were compared according to cognitive impairment status (impairment in any domain versus no impairment) using chi-square tests for categorical variables and *t*-tests for continuous variables. Multivariable linear regression models were used to examine associations between self-care and cognitive impairment, controlling for a number of potentially confounding factors including age, gender, education level, marital/cohabitation status, incident versus recurrent HF, recent HF-related hospitalization, depressive symptoms (from the Geriatric Depression Scale-5[38]), and history of stroke, chronic obstructive pulmonary disease, and renal disease. Assuming a prevalence of cognitive impairment of 50% in our sample and a mean (standard deviation [SD]) of 34 (5.5) points for the EHFScBS-9,[39] we estimated that this study would be powered at 80% ($\alpha = 0.05$) to find a minimum detectable difference of 1.3 points in mean self-care scores between patients with and without cognitive impairment.

In addition to the main analyses, we performed two sensitivity analyses: one examining the association of cognitive impairment and self-care only among patients with prevalent HF at time of hospital admission (n = 411) and another in which we imputed data for participants who did not complete the Digit Symbol Substitution Test, which was missing in 220 participants due to difficulties encountered when administering the paper and pencil test to acutely ill patients in a hospital setting. Imputation of missing values for the processing speed score was performed by applying an iterative expectation-maximization algorithm[40] to a model consisting of age, gender, education level, depressive symptoms, history of stroke, and memory and executive function scores to produce maximum likelihood estimates for DSST scores; a single imputed dataset containing complete cognitive data on all patients created by this procedure was used in these

secondary analyses. All analyses were performed using SAS version 9.2 (SAS Institute Inc, Cary, NC, USA) or STATA SE version 11 (StataCorp, College Station, TX, USA).

Results

Study sample

Of the 894 patients in the study sample, 577 patients had complete data on cognitive function and self-care. A total of 317 patients were excluded due to missing data: 298 patients were missing data on one or more cognitive tests; 12 were missing data on self-care, and seven were missing both cognition and self-care data. Of those missing data on cognitive tests (N = 305), the majority (220) were missing data on processing speed only, eleven were missing memory only, six were missing executive function only, and 68 patients were missing data on more than one cognitive test. Compared with the 577 patients with complete data, the 317 patients who were excluded due to missing cognitive or self-care data were significantly older (mean age 75 versus 71 years) and were more likely to have a history of HF (76% versus 69%) and other comorbidities including cardiovascular disease (61% versus 52%), diabetes (41% versus 34%), and stroke (18% versus 12%); all *P*-values <0.05. Patients with missing data were more likely to be impaired in executive function (62% versus 38%; $P < 0.001$) but did not differ significantly in rates of impairment in memory and processing speed. Self-reported adherence to self-care regimens did not differ significantly between included and excluded patients.

Sample characteristics

The 577 patients hospitalized for decompensated HF had an average age of 71 years (SD = 12.8, 88% >55 years old), 44% were female, and 90% self-identified as Caucasian (Table 1). More than two-thirds (72%) of the sample had a history of HF prior to the current hospitalization, and approximately one-quarter (24%) had been hospitalized for HF within the past 3 months. Two-fifths (40%) of patients reported high depressive symptoms. The prevalence of comorbid conditions was high, with 88% of patients reporting at least two other conditions in addition to HF and nearly one-third (30%) reporting five or more comorbid conditions.

Memory, processing speed, or executive function were impaired in 33.3%, 40.0%, and 56.0% of patients, respectively; more than three-quarters (79%) of patients were impaired in at least one of the three domains. Patients with cognitive impairment were significantly older, had less formal education, and had more comorbidities (all *P*-values < 0.001) (Table 1). Cognitively impaired patients were also more likely to have been hospitalized in the past 3 months (25.9% versus 18.0%, $P = 0.02$).

Table 1 Demographic and clinical characteristics according to level of cognitive impairment

Characteristic	Cognitive status (impairment in any domain)		*P*
	Impaired (n = 453)	Not impaired (n = 124)	
Age, years, n (%)			
<65	115 (25.4)	51 (41.1)	
65–74	105 (23.2)	40 (32.3)	<0.001
75–84	150 (33.1)	25 (20.2)	
85+	83 (18.3)	8 (6.5)	
Female, n (%)	190 (42.0)	64 (51.6)	0.06
Caucasian, n (%)	402 (91.0)	108 (88.5)	0.42
Lives with spouse/ partner, n (%)	222 (49.0)	68 (54.8)	0.25
Education, n (%)			
<High school	126 (27.8)	12 (9.8)	
High school graduate/ some college	175 (38.6)	37 (30.1)	<0.001
≥College graduate	152 (33.6)	74 (60.2)	
Recurrent HF, n (%)	331 (73.4)	80 (65.0)	0.07
Hospitalized for HF within 3 months, n (%)	111 (25.9)	21 (18.0)	0.022
Attended an HF clinic, n (%)	132 (29.1)	35 (28.2)	0.55
High depressive symptoms, n (%)[a]	185 (42.1)	41 (33.3)	0.08
Medical history, n (%)			
Cardiovascular disease	250 (55.2)	73 (58.9)	0.46
Myocardial infarction	145 (32.0)	44 (35.5)	0.47
Peripheral arterial disease	84 (18.5)	20 (16.1)	0.54
Hypertension	355 (78.4)	101 (81.5)	0.46
Diabetes	191 (42.2)	50 (40.3)	0.71
Stroke	59 (13.0)	10 (8.1)	0.13
Anemia	101 (22.3)	23 (18.6)	0.37
Cancer	63 (13.9)	15 (12.1)	0.60
Depression	65 (14.4)	13 (10.5)	0.27
Asthma/COPD	148 (32.7)	30 (24.2)	0.07
Renal disease	173 (38.2)	31 (25.0)	0.006
Number of comorbidities, n (%)[b]			
0–1	48 (10.6)	21 (16.9)	0.012
2–4	258 (57.0)	78 (62.9)	
5+	147 (32.5)	25 (20.2)	

Notes: [a]Based on Geriatric Depression Scale-5 responses; [b]number of comorbidities includes diagnoses of any conditions listed under "Medical history."
Abbreviations: COPD, chronic obstructive pulmonary disease; HF, heart failure.

Cognitive impairment and self-care

In unadjusted analyses, self-reported adherence to self-care activities did not differ significantly according to overall cognitive status (ie, impairment in any domain versus impairment in no domains; Table 2). Impairment in processing speed was associated with significantly better self-care,

Table 2 Self-care according to cognitive status and specific domains of cognitive impairment

Cognitive domain	Number (%) impaired	Self-care (EHFScBS-9) score[a] Mean score (SD)		*P*
		Impaired	Not impaired	
Memory	192 (33.3)	29.5 (7.5)	30.7 (7.4)	0.06
Processing speed	277 (48.0)	31.1 (7.0)	29.6 (7.8)	0.02
Executive function	323 (56.0)	30.8 (7.2)	29.7 (7.7)	0.07
Overall cognitive status[b]	453 (78.5)	30.5 (7.5)	29.6 (7.3)	0.25

Notes: [a]Range = 0–45, higher score signals better self-care; [b]impairment in any domain.
Abbreviations: EHFScBS-9, 9-item European Heart Failure Self-care Behaviour Scale; SD, standard deviation.

whereas mean self-care scores did not differ significantly according to impairment in memory or executive function (Table 2).

Linear regression was used to examine the association between cognitive impairment and reported self-care behaviors, adjusting for clinically or statistically significant covariates. Similar to findings from the unadjusted analyses, overall cognitive status was not associated with performance of self-care activities in multivariable adjusted regression models (Table 3).

When we examined impairment in specific domains, memory impairment was associated with significantly poorer performance of self-care activities in multivariable models controlling for demographics (β = −1.87, 95% confidence interval [CI] = −3.20 to −0.54) as well as in the fully adjusted model, which additionally controlled for clinical characteristics and impairment in other cognitive domains (β = −1.70, 95% CI = −3.08 to −0.32) (Table 3). Impairments in processing speed and executive function were not significantly associated with self-care in the adjusted models. Variance inflation factors in all multivariate analyses were <1.5, well below the recommended cutoff of 10, indicating that multicollinearity was not a major factor in the models.[41]

We performed two sensitivity analyses. The first examined the association of self-care practices with cognition among patients with prevalent (previously diagnosed) HF at the time of hospital admission (n = 411), who were more likely to have been educated about HF self-care prior to admission, and a second analysis was carried out to account for missing data on processing speed through the use of an imputed dataset. Findings from the sensitivity analysis restricted to patients with prevalent HF were similar to those from the full sample. However, although the direction of the associations were the same, the association between memory impairment and a

Table 3 Linear regression analysis of the association of cognitive impairment and engagement in self-care activities

	Unadjusted β (95% CI)	R^2	f^2	*P*	Model 1[a] β (95% CI)	R^2	f^2	*P*	Model 2[b] β (95% CI)	R^2	f^2	*P*
Cognitive impairment in any domain	0.88 (−0.61–2.37)	0.002	0.002	0.25	0.53 (−1.06–2.11)	0.031	0.032	0.51	0.44 (−1.06–2.05)	0.103	0.115	0.96
Domain of cognitive impairment												
Memory	−1.24 (−2.53–0.05)	0.006	0.006	0.06	−1.87 (−3.20–0.54)	0.043	0.045	0.006	−1.70 (−3.08 to −0.32)[c]	0.098	0.109	0.004
Processing speed	1.52 (0.30–2.74)	0.010	0.010	0.015	1.01 (−0.30–2.32)	0.034	0.036	0.13	1.19 (−0.173–2.56)[d]	0.107	0.120	0.09
Executive function	1.13 (−0.09–2.36)	0.006	0.006	0.07	1.27 (−0.01–2.55)	0.037	0.038	0.052	1.23 (−0.08–2.53)[e]	0.124	0.142	0.16

Notes: [a]Adjusted for age, education, gender, and living status; [b]adjusted for model 1 + incident versus recurrent HF, recent hospitalization for HF, depression, stroke, asthma/COPD, renal disease; [c]adjusted for model 2 + processing speed and executive function; [d]adjusted for model 2 + memory and executive function; [e]adjusted for model 2 + memory and processing speed.
Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; HF, heart failure.

lower self-care score was no longer statistically significant in the restricted sample, likely due to differences in power between the two analyses (β = −1.04, 95% CI = −2.61 to 0.52; Appendix 1). Similar findings were observed in all multivariable regression models conducted on the imputed dataset: memory impairment was associated with significantly poorer self-care, and impairment in executive function was associated with better self-care (data not shown).

Discussion

The current study examined the association of cognitive impairment and self-care practices in a large sample of older patients hospitalized with acute HF. More than three-quarters of our sample was impaired in at least one cognitive domain. Memory impairment was associated with significantly poorer adherence to HF self-care activities, while impairment in executive function was associated with better performance of self-care activities. Processing speed was not associated with HF self-care.

The prevalence of cognitive impairment observed in our sample is similar to previous studies that have reported rates of cognitive impairment of 30%–75% in patients with HF.[12,16–20,38,42] The high rate of cognitive impairment among patients with HF consistently reported across studies highlights the importance of cognitive screening in this high-risk population.

The few studies that have examined the association between cognitive impairment and HF self-care have reported inconsistent findings.[26,42] A study of 93 patients hospitalized with HF found that only certain self-care activities were compromised in cognitively impaired patients.[26] Specifically, patients with cognitive impairment reported poorer self-management behaviors (eg, recognizing symptoms of worsening HF, decision-making with regard to care-seeking) but similar self-maintenance behaviors (eg, daily weight monitoring) as patients with intact cognitive function. Another recent study[42] of 41 HF patients found that impaired memory or processing speed reported was associated with better self-care. Our study adds to the existing literature by examining the association between self-care and various domains of cognitive function in the context of a large and diverse sample of hospitalized older patients. Our mixed findings provide further evidence of the complicated relationship between cognitive impairment and self-care and suggest that impairment in memory may be associated with less engagement in self-care activities.

Memory impairment may influence HF patients' abilities to engage in effective self-care in several ways. First, memory impairment may inhibit learning and retention of information necessary to maintain disease stability, such as remembering the dosage and timing of medications or remembering to monitor weight daily. Patients with memory impairment may not recognize symptoms indicative of acute decompensation, hindering early actions that may prevent hospitalization. The present study included a very brief assessment of memory (five-word delayed recall) which could easily be incorporated into use with patients with HF seen in hospital or outpatient settings.

Our findings for processing speed and executive function were counterintuitive to our hypotheses. We suspect that these counterintuitive findings may be explained in part by the influence of factors that were unmeasured in our study such as patient anosognosia, (ie, a situation in which patients are unaware of their cognitive impairment), or caregiver support. A prior study[38] examining HF self-care in the context of memory and processing speed function found that patients with impairment in these domains reported better self-care; through qualitative analyses, the authors found that patients with cognitive impairment and adequate self-care scores reported receiving support in accomplishing self-care goals from family members. In comparison, patients with intact cognition and inadequate self-care scores reported less support from family members. Furthermore, because patients with impairments in processing speed or executive function may lack awareness of their deficit(s) more so than those with memory impairment,[43] these anosognosic patients may inaccurately report their self-care activities. Inconsistency in results between studies with regard to the association between impairment in cognition and self-care suggests that this relationship is complex and that replication of this work in larger samples, potentially with more objective measures of self-care, is needed to clarify these associations and to assess the accuracy of self-report of self-care activities among patients with cognitive impairment.

Strengths and limitations

The findings of this study are strengthened by the use of a large sample of patients with acute HF who were interviewed by trained nurses and physicians using standardized survey instruments. We examined the association between self-care activities and dysfunction in three specific cognitive domains.

However, a number of limitations to this study need to be acknowledged in interpreting our results. The study sample was restricted to patients without a medical history

of clinically diagnosed dementia who were free of delirium and could independently undergo a 45-minute interview, potentially reducing the generalizability of our findings; since the most severely cognitively impaired patients were excluded from the current study, our results likely represent an underestimation of the association between cognitive status and self-care behavior. Since the European Heart Failure Self-care Behaviour Scale does not have established cutoff scores to discriminate adequate from inadequate self-care, it is difficult to interpret the clinical significance of the small differences found in mean self-care scores between those with and without cognitive impairment. Our results are also limited by the use of self-report to assess participants' engagement in self-care. It is possible that patients who are cognitively impaired may be less able to accurately report self-care. To the best of our knowledge, no self-report HF self-care scale has been validated in patients with cognitive impairment. In addition, we did not have information on caregiver support received with self-care activities, which may play a role in the association between cognitive impairment and HF self-care.[42,44] We also did not have information on whether patients received educational interventions which could have affected their engagement in self-care activities; however, we found no differences by cognitive status in patients' prior attendance at an HF clinic (Table 1), where disease management education is often provided. In addition, previous research[5,42] has found HF-related knowledge to be poorly correlated with self-care activities, which suggests that education may have only a modest impact on self-care. Furthermore, we found similar results when we restricted the sample to patients with prevalent HF. We encountered substantial challenges in administering a cognitive assessment using a paper-and-pencil format to acutely ill hospitalized patients and advise future investigators to carefully consider the functional limitations that may face hospitalized patients when choosing the format of administration for surveys. Since executive function scores differed significantly between study participants and patients excluded due to missing cognitive and self-care data, the association between impairment in executive function and self-care should be interpreted with appropriate caution. Lastly, due to the cross-sectional nature of our study, we are unable to draw conclusions on the causal relationship between cognitive impairment and self-care; further research is needed to understand how cognitive impairment during hospitalization for acute HF impacts self-care practices after discharge.

Conclusion

Cognitive impairment is a common comorbidity of HF that may impact patients' abilities to carry out self-care behaviors to maintain health and prevent hospitalizations. Simple memory screenings may help to identify patients with HF who need assistance in accomplishing optimal self-care.[45] Further research is needed to examine the role that caregivers play in support of self-care in cognitively impaired patients and how cognitive impairment and adherence to self-care activities interact to produce long-term outcomes.

Acknowledgments

We wish to thank Catherine Emery, RN, Bruce Barton, PhD, and Aimee Kroll, MPH, for their assistance in data collection and statistical analyses. This research was made possible through funding from the National Institutes of Health (RO1 HL77248). Dr Saczynski was supported in part by funding from the National Institute on Aging (K01AG33643), Dr McManus was supported in part by funding from the NIH (KL2RR031981), and Ms Hajduk and Drs Saczynski, McManus, Gurwitz, and Goldberg were supported in part by funding from the National Heart Lung and Blood Institute (U01HL105268). Dr Spencer is supported by a Career Investigator Award from the Heart and Stroke Foundation of Canada.

Author contributions

Alexandra M Hajduk contributed to concept and design, data analysis, and preparation of the manuscript; Darleen M Lessard, to data acquisition and analysis, and preparation of manuscript; David D McManus, to clinical expertise and preparation of the manuscript; Stephenie C Lemon, to preparation of the manuscript, study design/data acquisition; Jerry H Gurwitz, to preparation of manuscript and interpretation of data; Frederick A Spencer, to preparation of the manuscript, study design/data acquisition; Robert J Goldberg, to study PI, concept and design, and preparation of the manuscript; Jane S Saczynski, to concept and design and preparation of the manuscript. All authors critically reviewed and approved the final proof of the manuscript.

Disclosure

The authors report no conflicts of interest in this work.

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Appendix 1 Linear regression analysis of the association of cognitive impairment and engagement in self-care activities among patients with prevalent HF at hospital admission (n = 411)

	Unadjusted	R^2	f^2	*P*	Model 1[a]	R^2	f^2	*P*	Model 2[b]	R^2	f^2	*P*
	β (95% CI)				β (95% CI)				β (95% CI)			
Cognitive impairment in any domain	1.06 (–0.70–2.82)	0.003	0.003	0.24	1.13 (0.73–3.00)	0.030	0.031	0.23	0.96 (–0.91–2.83)	0.101	0.113	0.31
Domain of cognitive impairment												
Memory	–1.13 (–2.61 to –0.34)	0.006	0.006	0.13	–1.40 (–2.92–0.12)	0.034	0.035	0.07	–1.04 (–2.61–0.52)[c]	0.109	0.123	0.19
Processing speed	1.14 (–0.25–2.53)	0.006	0.006	0.11	1.03 (–0.47–2.53)	0.031	0.032	0.18	0.97 (–0.57–2.51)[d]	0.111	0.125	0.22
Executive function	1.01 (–0.41–2.42)	0.005	0.005	0.16	1.33 (0.14–2.80)	0.034	0.035	0.08	1.48 (–0.00–2.97)[e]	0.111	0.125	0.050

Notes: [a]Adjusted for age, education, gender, and living status; [b]adjusted for model 1 + incident versus recurrent HF, recent hospitalization for HF, depression, stroke, asthma/COPD, renal disease; [c]adjusted for model 2 + processing speed and executive function; [d]adjusted for model 2 + memory and executive function; [e]adjusted for model 2 + memory and processing speed.

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; HF, heart failure.