Cognition and Health Literacy in Patients with Hypertension

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BACKGROUND: Approximately half of the US population has marginal or inadequate health literacy, a measure highly associated with health outcomes. This measure is often linked to age and education, but recent evidence from patients with chronic heart failure suggests that much of age-related variability in health literacy can be explained by cognitive abilities (e.g., working memory, processing speed).

OBJECTIVE: We examined the role of cognitive and sensory abilities as mediators of age and education in determining functional health literacy among patients with hypertension.

PARTICIPANTS: Four hundred ninety two community-dwelling adults diagnosed with hypertension (aged 21 to 92 years) participated. They were primarily female (73%), African-American (68%), and reported taking on average 7.8 prescribed medications.

MEASUREMENTS: Before participation in a medication adherence intervention study, participants completed a battery of health literacy-related tasks. They completed tests that measured health literacy [Short Test of Functional Health Literacy in Adults (STOFHLA)], cognitive abilities (working memory, processing speed), sensory abilities (visual acuity and hearing), and physical health.

RESULTS: Regression analyses showed that health literacy was related to age, education, and race (accounting for 24.4% of variance in STOFHLA scores). Cognitive ability accounted for an additional 24% of variance and greatly reduced the influence of age, education, and race (by 75%, 40%, and 48%, respectively).

CONCLUSIONS: When controlling for cognitive and sensory variables, the association of age and education with STOFHLA scores was dramatically reduced. Thus, future interventions aimed at improving self-care for patients with low health literacy should aim to reduce demands on patients' cognitive abilities.

KEY WORDS: health literacy; hypertension; working memory; aging.

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INTRODUCTION

The results of the 2003 National Assessment of Adult Literacy¹ indicated that approximately half of the U.S. population has inadequate or marginal functional health-related literacy, and the proportion increased with age.² As health literacy has been shown to be directly associated with health outcomes, health knowledge, and successful navigation of the health care system,^{3–6} it is crucial that older adults with poor health literacy be identified and their potential deficits compensated for (e.g., by reducing the complexity of navigating the health care system, or by assigning health care assistants to facilitate self-care). A better understanding of the specific skills and abilities that are impaired in low-literacy patients will guide the development of these interventions.

Health literacy has been measured by tests of reading and understanding health-related materials, such as the Short Test of Functional Health Literacy in Adults (STOFHLA).^{7,8} Because these tests are generally presented in verbal form, successful performance depends in part on general literacy and language comprehension.³ Theories of comprehension identify specific processes (e.g., word recognition; combining word meanings to form idea units) that depend on more general cognitive abilities, such as the rate of mental processing and working memory capacity.⁹ Age-related differences in these abilities help explain corresponding differences in comprehension.¹⁰ Thus, general cognitive abilities should be important components of health literacy models designed to help explain the effects of age and other demographic variables on health literacy. However, relatively little is known about the specific links between these cognitive factors and performance on tests of functional health literacy.

Morrow et al. provided some evidence for associations between general cognitive abilities and health literacy, as measured by the STOFHLA.^{11,12} That study investigated correlates of health literacy among older adults with chronic heart failure (CHF), a common condition that requires a high level of self-care and therefore would likely be highly dependent on adequate health literacy.¹³ In addition to demographic factors, patients in this study were assessed across a battery

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that measured facets of cognition relevant to comprehension (processing speed, working memory) in an effort to determine the potential relationship between health literacy and general cognitive abilities. There was a significant independent effect of cognitive ability on STOFHLA performance, even when education, age, and other demographic factors were controlled.

The present study builds on the Morrow et al. study to provide further support for models that explain the association between age and health literacy in the context of cognition.¹¹ Two limitations in the earlier study were addressed. First, the findings related to cognitive ability and functional health literacy may have limited generalizability because all participants were older adults with CHF. Second, the previous study was limited in its ability to explore associations between demographic factors and health literacy because there was only a modest relationship between health literacy and aging. Thus, the present study investigated associations between cognitive ability and health literacy in a different patient population with a wider age range than in the earlier study.

We examined patients with hypertension, a relatively common medical condition that requires precise and consistent adherence to medication regimens to reduce symptoms.¹³ In the absence of adequate self-care or appropriate professional assistance, uncontrolled hypertension is a primary risk factor for stroke and heart failure.¹⁴ Successful treatment of hypertension, like CHF, is likely to be influenced by patients' ability to navigate the health care system, which in turn requires health literacy. Indeed, previous studies have indicated a link between health literacy and knowledge of self-care and self-reported health outcomes in hypertensive patients.^{15,16,17}

As in Morrow et al., we focused on the relationships between age, general cognitive abilities, and health literacy.¹¹ If the results of this previous study are generalizable, we should find effects of cognitive ability on functional health literacy independent of education and health status. Furthermore, we expected cognitive ability to explain any age-related differences in health literacy.

METHODS

This study involved a volunteer sample of 492 community-dwelling adults, aged 21 to 92, who had been diagnosed with hypertension and were taking at least one hypertension medication. Participants were recruited for a pharmacy-based patient education intervention study intended to improve adherence to medications prescribed for hypertension. Recruitment was through a Midwestern, county-managed urban hospital.¹⁸ Most participants (95%) completed all measures reported in this article during baseline data collection for the intervention study (i.e., before random assignment to the intervention or usual care control groups of that study).

Demographic (age, gender, race) and education variables were measured at study recruitment via a self-report questionnaire. Participants self-identified their racial group by choosing from a set of options. Only six individuals classified themselves as neither African-American nor white, and they were included with white participants to form an "other" race category. Thus, for subsequent regression analyses, racial groups were coded as African-American or other. The participants' hypertension status was verified according to measures consistent with Joint National Committee guidelines: patients

were diagnosed with hypertension by a physician, had blood pressure at or above 140/90 mm Hg, and were currently taking medication prescribed for hypertension.¹⁹ In addition to verifying hypertension for all participants, comorbidities, measured by the Charlson Comorbidity index,²⁰ and complication status (i.e., the presence or absence of secondary factors that aggravated the symptoms of hypertension) was recorded. We also report participants' systolic blood pressure, which has been found to be associated with cognitive functioning in older adults when measured over time.²¹

Health-related literacy was measured using the reading component of the STOFHLA.⁷ The test generally requires 7 minutes to administer and is intended to determine participants' ability to read and understand written health-related passages with readability levels of 4.3 and 10.4 grade level (Gunning-Fog index). Scores range from 0 to 36, such that a score of 0–16 reflects inadequate health literacy, 17–22 marginal literacy, and 23–36 adequate literacy. STOFHLA scores are generally associated with health outcomes and are typically lower for older adults.²²

Participants were provided a battery of measures of sensory and cognitive abilities that are linked to comprehension.⁹ Visual function was measured with the Snellen chart (a sequence of letters read from a specific distance). Auditory function was assessed via the Speech Discrimination Screening Task from the Arizona Battery for Communication Disorders of Dementia,²³ which tests the ability to discriminate word pairs that differ in their first phoneme (e.g., "bare" and "dare").

Verbal working memory (i.e., the ability to store and manipulate verbal information simultaneously) was assessed by the listening span task, in which participants answer questions about increasingly long sets of sentences (1–6 sentences) and must recall the final word of each sentence.²⁴ The working memory measure was the size of the sentence set for which the participant could reliably recall the sentences' final words. In previous studies, age-related differences in this task have been shown to account for part of the age-related variance found in memory and reasoning tasks.²⁴ Processing speed was measured by performance in the letter comparison and pattern comparison tasks, which require participants to rapidly decide whether pairs of letters or sets of line patterns are identical.²⁵ Participants are given limited time to perform the task, and the number of correct comparisons serves as a measure of processing speed. As in the working memory task, age-related differences in performance on these tasks account for some age-related variance in reasoning and memory tasks.^{25,26} Moreover, processing speed and working memory measures were associated with individual differences in STOFHLA performance among older adults with CHF in Morrow et al.¹¹

Plan of Analysis

We tested whether health-related literacy, in a diverse sample of adults with hypertension, was associated with sensory and cognitive abilities and whether these associations mediated the frequently documented effects of demographic variables (e.g., age) on health literacy.²⁷ To examine this, we conducted a series of regression analyses to identify correlates of health literacy. First, we present a series of simple linear regressions that show the effects of each independent variable on STOFHLA scores. These analyses were examined in the context

of correlations describing the relationship between all demographic and cognitive/sensory variables, which guided the development of models for the subsequent multiple regression analyses.

Next, we examined the relative effects of those variables that were significantly associated with STOFHLA scores in the simple linear analyses, with the influence of the other variables controlled. Following Morrow et al., we first examined the association of the demographic and health variables (age, race, gender, comorbidity) with the STOFHLA measure (step 1).¹¹ Next, the contributions of demographic and health variables were tested with education added to the model (step 2). Finally, the relative influence of demographic, health, and education variables was examined with the cognitive and sensory variables added to the model (step 3).

RESULTS

Participants

The majority (73%) of participants (age range, 21–93 years old) were female. Approximately 68% were African-American, and the remaining participants were non-Hispanic white (30%), Hispanic (<1%), Native American (<1%), and Asian (<1%). On average, participants reported 3.2 comorbid conditions and were taking a mean of 7.8 prescribed medications (SD=3.5) at the time of the study. Twenty-three percent of participants had marginal or inadequate health-related literacy (STOFHLA score <16), which is consistent with previous studies involving older adult samples.²⁷

Simple Linear Regression Analyses of Health Literacy

We first examined simple associations between the STOFHLA measure and each demographic, health, and cognitive/sensory measure. Table 1 presents mean and standard deviation values for the continuous demographic and individual difference variables separately for the African-American and other groups. Age was negatively correlated with the health literacy measure ($r=-.28$, $p<.05$), as well as with the cognitive and sensory ability measures (r values $-.10$ to $-.40$, all p values $<.05$). To further examine age-related differences in these variables, Table 1 presents means separately for participants

older than (and including) 60 years and younger than 60 years. Age comparisons were consistent with the correlations.

Table 2 presents results of these simple regression analyses with STOFHLA scores separately regressed on each independent variable. The scores were lower for participants who were male, African-American, older, less educated, had more comorbidities, and scored lower on all cognitive ability measures, as well as on the speech discrimination and the Snellen tests. Systolic blood pressure was not associated with STOFHLA scores, perhaps because the comparison was concurrent. A comparison of the R^2 values, interpreted here as the percentage of variation in STOFHLA scores directly explained by variables in the regression model, indicated that education ($R^2=17.7\%$), the measures of processing speed and working memory (comparison test $R^2=32.9\%$, listening span $R^2=8.0\%$), and age ($R^2=6.1\%$) accounted for the largest amount of variability in health literacy.

Multivariable Regression Analyses of Health Literacy

Based on the simple regression analyses, we examined which patient variables were associated with health literacy while controlling for relationships among these variables (e.g., Table 1 shows that African-American participants were slightly older – and scored lower on the cognitive measures – compared to other participants). Table 3 shows a series of multivariable regressions. First, STOFHLA scores are evaluated with a regression model that included demographic and comorbidity variables (step 1). These variables had similar relationships with literacy compared to the simple linear regressions. Adding years of education (step 2) explained an additional 12% of the variance in STOFHLA scores and had little impact on the variance explained by the demographic variables. Finally, entering all of the cognitive and sensory variables (step 3) accounted for an additional 24% of variance in STOFHLA scores and strongly mediated the effects of age, race, and education on health literacy (with decreases in beta values of 75%, 40%, and 48%, respectively). It is important to note that, in this final step, more variance in STOFHLA scores can be accounted for by cognitive variables than by education (although the improvement in model fit may be partly explained by the number of additional factors added to our model in this step), and the age-STOFHLA relationship is attenuated to a far greater extent than what is observed in step 2 (Beta is reduced from $-.20$ to $-.16$ after step 2 and from $-.16$ to $-.05$ after step 3).

Table 1. Means and Standard Deviations for Continuous Demographic and Individual Difference Variables, by Racial Group and Age (n=492)

Variable	Overall (n=492)	African American (n=336)	Other* (n=156)	p	Age<60 (n=312)	Age>=60* (n=180)	p
Age, years	56.6 (10.8)	56.9 (10.5)	55.9 (8.7)	.36	–	–	–
Education, years	11.3 (2.4)	11.4 (2.3)	10.9 (2.6)	.04	11.7 (2.3)	10.6 (2.5)	<.01
Number of comorbidities	3.2 (1.5)	3.1 (1.4)	3.3 (1.6)	.12	2.9 (1.4)	3.5 (1.4)	<.01
Systolic blood pressure	139.0 (21.8)	140.8 (22.7)	135.4 (19.6)	.01	137.6 (21.4)	141.6 (22.3)	.05
STOFHLA score	28.9 (7.8)	28.1 (8.2)	31.0 (6.6)	<.01	30.6 (6.6)	26.1 (9.0)	<.01
Comparison task score	19.6 (5.5)	19.2 (5.6)	20.6 (5.3)	.02	21.2 (5.2)	16.8 (5.0)	<.01
Listening span score	1.8 (0.9)	1.7 (0.9)	1.9 (0.9)	<.01	1.8 (0.9)	1.7 (0.9)	.03
Snellen	72.1 (14.5)	72.4 (14.8)	71.5 (13.8)	.50	74.3 (14.3)	68.5 (14.1)	<.01
Speech discrimination	17.3 (1.4)	17.3 (1.5)	17.4 (1.0)	.21	17.4 (1.4)	17.2 (1.3)	.31

Table 2. Results of Simple Linear Regression Analyses of STOFHLA Scores

Variable	R ²	β	SE	F
Demographic				
Age	6.10	−0.21	.04	30.3 [§]
Gender	1.33			6.3 [†]
Female		2.43	.97	
Male		0.00		
Race	2.80			13.5 [§]
African American		−3.39	.93	
Other		0.00		
Charlson comorbidity Index	2.02	−0.92	.29	9.6 [‡]
Systolic blood pressure	.001	−.01	.02	.05
Education	17.73	1.6	.16	100.4 [§]
Cognitive				
Letter and pattern comparison task	32.91	0.96	.06	226.6 [§]
Listening span task	7.96	2.12	.34	39.8 [§]
Sensory				
Snellen test of visual function	3.16	.11	.03	15.1 [§]
Speech discrimination test of auditory function	.07	1.82	.30	36.5 [§]

†*p* < .05‡*p* < .01§*p* < .001

Moreover, an alternative model in which the sensory and cognitive variables were entered without education accounted for almost as much variability in STOFHLA scores as the model with all variables entered (step 3 in Table 3) (*R*² = 46% vs 49%).

DISCUSSION

Older adults generally score lower on health literacy measures than younger adults.⁸ We investigated whether this relationship is due in part to age-related differences in general cognitive and sensory abilities. There was a substantial improvement in model-fit observed when entering cognitive and sensory variables in the regression model after controlling for demographic and education variables, demonstrating a strong influence of these variables on functional health literacy. When controlling cognitive and sensory variables, STOFHLA scores had only a marginally significant association with age, which replicates the findings of Morrow et al.¹¹ The impact of cognitive and sensory variables on health literacy is predicted by theories of language comprehension.^{9,10} According to these theories, comprehension processes, such as activating word meanings and combining them to form idea units, place demands on general cognitive abilities such as mental processing speed and working memory capacity.

The mediating effect of cognitive variables on the age-STOFHLA relationship is similar to, but substantially stronger than, that of Morrow et al.¹¹ In particular, the variance in STOFHLA performance explained by education was considerably less than that explained by the cognitive and sensory variables (*R*² increases of 12.4% and 24.5%, respectively) in the present study. Our results indicate that, not only are cognitive variables more strongly associated than education with STOFHLA scores, but much of the education-STOFHLA relationship itself may be a proxy for cognitive ability (see also Manly et al.²⁸).

While our findings suggest that cognition is more important than education for explaining differences in health literacy, we

note that years of education is a relatively crude measure of educational attainment. More sensitive measures of quality and quantity of education might better predict health literacy differences.

There are several possible explanations for why cognitive measures were more important for explaining age-related differences in health literacy in the present study compared to Morrow et al.¹¹ First, the age range in the present study was substantially larger than in the earlier study (21–93 years vs 47–89 years, respectively), which would allow for a stronger initial age-STOFHLA relationship. Indeed, the correlation between age and STOFHLA score in this study (*r* = −.28) was more than twice the effect reported in the previous study (*r* = −.11).

Another possible explanation relates to the fact that hypertension was investigated in the present study while CHF was the focus of the earlier study. There is a well-documented negative association between hypertension and cognitive functioning, especially when high blood pressure is uncontrolled for an extended period of time.^{29,30} It is possible that studying hypertension may have afforded a wider range of scores related to cognitive and sensory functioning compared to CHF. Although this conclusion is tempered by the relatively high rate of hypertension in Morrow et al. (approximately 90% of participants were also hypertensive),¹¹ participants with CHF would be more likely to present the most severe symptoms of hypertension. In addition, cognitive impairment is independently associated with CHF.³¹ As such, to whatever extent hypertension influences cognitive functioning in already-impaired adults, the resulting range of cognitive functioning would be more compressed for patients with CHF than for those with more varied symptoms of hypertension, as in the present study.

This study extends the relationship between cognitive and sensory variables with STOFHLA scores found in Morrow et al.¹¹ to a broader and, generally, healthier patient population (hypertensive patients). The present findings converge with

Table 3. Results of Multivariable Regression Analyses of STOFHLA Scores

Variable	Step 1	Step 2	Step 3
Model R ²	12.0%	24.4%	48.9%
Model fit	<i>F</i> (4,447) = 15.28 [§]	<i>F</i> (5,446) = 28.74 [§]	<i>F</i> (9,429) = 45.7 [§]
Age	−0.20 [§]	−0.16 [§]	−0.05*
Gender			
Female	1.69 [†]	1.63 [†]	1.85 [‡]
Male	0.00	0.00	0.00
Race			
African American	−2.98 [§]	−3.42 [§]	−1.81 [‡]
Other	0.00	0.00	0.00
Charlson comorbidity index	−0.29	−0.12	0.05
Education		1.19 [§]	0.62 [§]
Letter and pattern comparison task			0.51 [§]
Listening span task			2.31 [§]
Snellen test of visual function			−0.01
Speech discrimination task			0.60 [‡]

**p* < .10†*p* < .05‡*p* < .01§*p* < .001

previous studies^{11,12} to suggest that age-related differences in functional health literacy reflect general cognitive and sensory abilities. These abilities may also help explain the association of health literacy with self-care (e.g., medication adherence) and with health outcomes.⁴⁻⁶

Our findings have implications for clinical practice. Augmenting global health literacy measures with measures of cognitive function may help identify the specific impairments that reduce a patient's ability to maintain adequate self-care. With a more complete view of an individual patient's abilities, health care providers can tailor interventions to that patient's strengths (e.g., using familiar words and concepts) while reducing demands on vulnerable abilities (providing explicit text to reduce the need for inferences^{32,33}).

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Conflict of Interest: None disclosed.

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