Article

HEALTH EDUCATION & BEHAVIOR

Health Education & Behavior
1–9

DOI: 10.1177/10901981221079742
journals.sagepub.com/home/heb
SAGE

Health Literacy, Numeracy, and Dietary Approaches to Stop Hypertension Accordance Among Hypertensive Adults

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Abstract

Background: Health literacy (HL) and health numeracy (HN), the ability to interpret and act on quantitative health information, are important for hypertension self-management such as limiting sodium intake. We examined associations of HL, HN, and Dietary Approaches to Stop Hypertension (DASH) diet accordance. **Participants:** Among 1,073 hypertensive adults enrolled in a Baltimore, Maryland–based cohort study, we performed a cross-sectional analysis. Rapid Estimate of Adult Literacy in Medicine (REALM) measured HL and Test of Functional Health Literacy in Adults (TOFHLA) numeracy score measured HN. **Method:** DASH accordance was based on nine key nutrients. Linear regression models estimated associations of HL and HN with DASH total and sodium score, inclusive of dietary supplement data. **Results:** In our sample, 39% of participants were male, 66% were Black, 40.2% lived in poverty, and 29.5% reported food insecurity. Fully, 32.5% had limited HL and 14.5% had limited HN. Mean DASH score overall was 2 (range = 0–7.5); only 6.9% were DASH accordant (score ≥4.5). In age and sex adjusted models, higher REALM was associated with a higher DASH score in the overall sample; the relationship of HN with DASH was statistically significant among White but not Black participants. Educational attainment appeared to explain both findings. There were no significant associations between HL or HN and DASH sodium scores. **Conclusion:** Differences in educational attainment explained the relation of higher HL and greater accordance to the DASH diet in a population of hypertensive adults. Understanding these factors is vital to reducing disparities in hypertension and its sequelae.

Keywords

diet, general terms, health equity, health literacy, hypertension, *nutrition*, quantitative methods, social determinants of health

Health literacy 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" (Selden et al., 2000). Health numeracy, defined as "the degree to which individuals have the capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, biostatistical, and probabilistic health information needed to make effective health decisions" (Golbeck et al., 2005), also plays an important role in an individual's ability to manage their health conditions. Health literacy and numeracy are important skills for people with hypertension (Supplemental Figure), which affects almost half of adults in the United States (Centers for Disease Control and Prevention, 2021) and is a major risk factor for cardiovascular disease, cerebrovascular disease, and kidney disease—leading causes of death in the United States (Kochanek et al., 2019).

Higher health literacy is associated with greater knowledge of hypertension (Du et al., 2018), which may affect the ability to manage the disease, particularly in regard to dietary modifications recommended for blood pressure control. Health literacy and numeracy are also predictors of dietary modification skills for controlling blood pressure, such as using food labels when choosing foods (Cha et al., 2014; Nogueira et al., 2016) and consuming fruit and soda

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(Nogueira et al., 2016). In a previous analysis of the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) cohort, health literacy was positively associated with nutrient-based diet quality in this urban population of adults (Kuczmarski et al., 2016).

Black Americans experience a greater burden of hypertension (56%) than White Americans (48%; Centers for Disease Control and Prevention, 2021) and racial disparities in health literacy may be a contributor. The 2003 National Assessment of Adult Literacy found that only 2% of Black individuals had proficient health literacy, compared with 14% of White individuals, and 24% of Black persons had below basic health literacy, compared with 9% of White persons (Kutner et al., 2006).

The Dietary Approaches to Stop Hypertension (DASH) diet is a dietary pattern high in fruits, vegetables, and low-fat dairy foods, whereas low in total and saturated fat, as well as sodium (Sacks et al., 2001), which is recommended for the treatment of hypertension (Whelton et al., 2017). The DASH dietary pattern is the diet best demonstrated to be effective for lowering blood pressure. In hypertensive adults, the DASH diet has produced overall reductions in systolic blood pressure of approximately 11 mmHg (Appel et al., 1997). The DASH diet has been documented to be especially effective at lowering blood pressure among Black Americans (Svetkey et al., 1999). However, Black adults are more likely to have lower DASH accordance scores than White Americans (Mellen et al., 2008). A study by Hutchison et al. also found that Black patients were less likely to follow low-sodium dietary guidelines than were White patients (8.3% vs. 34.9%; Hutchison et al., 2014).

Prior research on the relationship between health literacy and diet has focused on the general population or people with diabetes (Carrara & Schulz, 2018). A previous study by Hutchison et al. assessed the association between health literacy and following a low-salt diet for patients with hypertension and the relationship was not significant, although diet adherence was measured using self-report (Hutchison et al., 2014). This study aims to contribute to the present literature by further understanding the relationship between health literacy, as well as health numeracy, and diet quality specifically for those with hypertension, through examining diet quality and potential accordance with treatment guidelines, using DASH diet accordance scores. In addition, due to higher prevalence of hypertension in Black Americans, examining these relationships in a cohort inclusive of many Black Americans would be important. To inform future efforts to mitigate disparities in hypertension, we aimed to determine the association between health literacy, health numeracy, and DASH diet accordance, including sodium intake, for individuals with hypertension, utilizing data from the HANDLS study. We expected to find that health literacy and health numeracy would predict DASH diet accordance, as well as sodium intake.

Method

Study Design and Population

We examined cross-sectional data from the National Institute on Aging, HANDLS study, a population-based cohort study initiated in 2004 to examine the relationships among race, socioeconomic status (SES), and health. Study participants were Black and White urban adults aged 30 to 64 years, sampled representatively across a range of SES from 13 neighborhoods in Baltimore City, Maryland. The National Institutes of Health, National Institute of Environmental Health Sciences Institutional Review Board approved the study protocol and all participants provided written informed consent (Evans et al., 2010).

We examined data from HANDLS Wave 3, which were collected between 2009 and 2013 in two parts. The first part of data collection took place on a mobile research vehicle (MRV) and included a medical examination, first 24-hour dietary recall, cognitive evaluation, physiological assessments, health literacy measures, and laboratory measurements. The second data collection visit took place through phone interview and included the second 24-hour dietary recall and dietary supplement questionnaire. HANDLS recruited 3,720 participants at Wave 1. Our sample consisted of those with self-report of hypertension and taking antihypertensive medication who completed their Wave 3 visit, the Rapid Estimate of Adult Literacy in Medicine (REALM), and the Test of Functional Health Literacy in Adults (TOFHLA), resulting in a sample of $n = 1{,}073$.

Measurements

Predictors. Health literacy was measured using the REALM, which is an oral reading and recognition test that measures the ability to pronounce 66 common medical words (Davis et al., 1993). The highest possible score is 66, which indicates that all words were pronounced correctly. Health numeracy was measured using the numeracy subscore of the TOFHLA, which is a numerical ability test consisting of 17 questions testing the ability to understand monitoring measurements, appointment information, financial assistance, and prescription medication bottle labels (Parker et al., 1995). The numeracy score was multiplied by 2.941 to obtain a scaled score out of 50. The REALM and TOFHLA were administered during Wave 3. The Wide Range Achievement Test, Version 3 (WRAT-3) measured general literacy in the baseline HANDLS study. Due to high correlation with REALM ($r = .78$, $p < .01$), WRAT-3 was excluded from the analysis to avoid multicollinearity.

Outcomes. The method for measuring accordance with the DASH diet in the HANDLS cohort has been previously described (Crews et al., 2015). Nonprescribed accordance to a DASH-like diet by study participants was measured using multiple dietary recalls. Food and beverage intakes

were collected using the U.S. Department of Agriculture's Automated Multiple Pass Method, a computerized methodology, on 2 days separated by 7 to 10 days (Moshfegh et al., 2008). This method was supplemented by measurement aids, including measuring cups, spoons, and an illustrated Food Model Booklet to assist in estimating accurate quantities of food and beverages consumed. The first dietary recalls were administered in person, and the second recalls by phone. All were administered by trained interviewers. The dietary recalls were coded using Survey Net, matching foods consumed with codes in the Food and Nutrient Database for Dietary Studies, Version 5. Energy and selected nutrient intakes were calculated for each recall day (U.S. Department of Agriculture, Agricultural Research Service, 2008). There were no significant differences in energy or nutrient intakes between the first and second recall days. The recalls represented both weekend and weekday consumption patterns, and there were no differences between energy and nutrient intakes by day of the week.

Dietary supplement intake information was collected after the second dietary recall. Detailed information was collected about use of over-the-counter vitamin and/or mineral supplements with and without botanicals, antacids, and prescription supplements over the past 24 hours. The dietary supplement questionnaire and descriptions about the collection and processing of dietary supplement data are published elsewhere (HANDLS Study, 2007). Data on supplement intake were added to data on mean nutrient intake from dietary recall to calculate a DASH diet accordance score inclusive of dietary supplements as nutrient intake levels could potentially change from being nonaccordant without accounting for supplements to accordant after accounting for supplement intake.

For this study, the mean nutrient values were used to assess accordance to the DASH diet, and DASH diet accordance scores were calculated as developed by Mellen et al. (2008). The goals for nine target nutrients (calcium, cholesterol, fiber, magnesium, potassium, protein, saturated fat, total fat, and sodium) were indexed to total energy intake. A score of 1 was defined by meeting the goal for a target nutrient, and a score of 0.5 was defined by meeting an intermediate goal for a target nutrient. The maximum DASH score was 9 and DASH accordance was defined by a score of 4.5 or greater (Mellen et al., 2008).

Covariates. Race was self-reported (Black or White) during the initial household survey; additional demographic data, including age, sex, level of educational attainment, report of a regular source of health care, health insurance status, income, food security, and poverty status were also assessed. An MRV was the site of health care provider–ascertained medical history and physical examination. Relevant comorbid disease conditions were determined through medical history by self-report and included kidney disease, diabetes, and cardiovascular disease (defined as self-report of coronary artery disease, heart attack, stroke, or congestive heart failure). Anthropometric measures, including height and weight, were collected and used to calculate body mass index (BMI). Tobacco use was defined as self-report of currently smoking cigarettes. Alcohol use was defined as self-report of being a current alcohol user.

Statistical Analysis

Differences in demographic and participant characteristics, stratified by health literacy and health numeracy status, were examined using *t* tests or Wilcoxon rank-sum tests for continuous variables and Fisher's exact tests for categorical variables. To compare health literacy and numeracy score groups, health literacy scores were defined as adequate (score of 60 or higher out of 66) or limited (score of 59 or lower out of 66); health numeracy scores were defined as adequate (score of 38 or higher out of 50) or limited (score of 37 or lower out of 50). Adequacy score definitions were based on existing literature (Fraser et al., 2013).

Multivariable linear regression was used to examine the relationship of health literacy and numeracy measures to DASH diet accordance overall and stratified by race, while adjusting for potential confounders. Potential confounders included age, sex, educational attainment, income, poverty status, health insurance status, regular source of health care, food security, BMI, tobacco use, and alcohol use. Model 1 included REALM, TOFHLA, and DASH total and sodium score (with and without supplements). Model 2 added age and sex, and Model 3 added educational attainment. Model 4 added the remaining potential confounders of income, poverty status, health insurance status, regular source of health care, food security, BMI, tobacco use, and alcohol use. We performed additional analyses stratifying the sample by race as the interaction term between TOFHLA and race was statistically significant. A two-sided $p < .05$ was used as the level of significance for all tests. All analyses were completed using Stat Version 15.1 (Stata-Corp, College Station, TX).

Results

Participant Characteristics

Our analyses included 1,073 participants with self-report of hypertension (Table 1). Mean participant age was 55.7 years; 39% were male and 66% were Black. Overall, 32.5% of participants had limited health literacy and 14.5% had limited health numeracy. As REALM and TOFHLA were only moderately correlated ($r = .345$), both were included in the same model. On the REALM, 67.5% of participants had a high school reading level, 23.1% had a grade level of seventh to eighth grade, 7.9% had a grade level of fourth to sixth grade, and 1.5% had a grade level of third grade and below. Participants with limited health literacy and numeracy were more likely to be Black, live in poverty, have fewer years of education, and have an income less than US$20,000

Table 1. HANDLS Study Participant Characteristics, Overall and by Health Literacy and Health Numeracy.

Characteristic	*N* for analysis	Overall	Health literacy[a]			Health numeracy[b]		
			Adequate	Limited		Adequate	Limited	
			724 (67.5%)	349 (32.5%)	*p* value	917 (85.5%)	156 (14.5%)	*p* value
Age, mean (*SD*)	1,073	55.7 (8.3)	55.8 (8.5)	55.6 (7.9)	.70	55.6 (8.4)	56.3 (7.6)	.33
Male gender, *n* (%)	1,073	416 (38.8)	253 (34.9)	163 (46.7)	<.01	345 (37.6)	71 (45.5)	.06
Black, *n* (%)	1,073	705 (65.7)	429 (59.3)	276 (79.1)	<.01	590 (64.3)	115 (73.7)	.023
Poverty, *n* (%)	1,073	431 (40.2)	247 (34.1)	184 (52.7)	<.01	354 (38.6)	77 (49.4)	.013
Education, mean (*SD*)	1,054	12.4 (2.9)	13.0 (2.9)	11.2 (2.3)	<.01	12.6 (2.9)	11.2 (2.6)	<.01
Income <US$20,000, *n* (%)	767	372 (48.5)	216 (40.1)	156 (68.4)	<.01	300 (45.3)	72 (68.6)	<.01
Health insurance, *n* (%)	815	676 (82.9)	473 (84.8)	203 (80.0)	.045	577 (82.9)	99 (83.2)	.99
Regular health care professional, *n* (%)	1,056	759 (71.9)	526 (73.8)	233 (67.9)	.049	654 (72.4)	105 (68.6)	.33
Food insecurity, *n* (%)	799	236 (29.5)	152 (27.6)	84 (33.9)	.08	194 (28.4)	42 (36.5)	.08
Self-reported kidney disease, *n* (%)	1,073	82 (7.6)	56 (7.7)	26 (7.5)	.90	68 (7.4)	14 (9.0)	.51
Self-reported diabetes, *n* (%)	1,073	308 (28.7)	196 (27.1)	112 (32.1)	.098	254 (27.7)	54 (34.6)	.09
Self-reported cardiovascular disease, *n* (%)	1,073	185 (17.2)	117 (16.2)	68 (19.5)	.20	153 (16.7)	32 (20.5)	.25
Current cigarettes, *n* (%)	839	368 (41.2)	232 (38.2)	136 (47.6)	.01	314 (40.7)	54 (44.6)	.43
Current alcohol, *n* (%)	993	502 (50.6)	339 (50.1)	163 (51.6)	.68	437 (51.2)	65 (46.4)	.32
BMI, mean (*SD*)	1,072	32.5 (8.3)	32.7 (8.2)	32.3 (8.6)	.43	32.8 (8.5)	31.3 (7.3)	.04

[a]Measured using Rapid Estimate of Adult Literacy in Medicine (REALM); adequate = 60 or higher out of 66, limited = 59 or lower out of 66. [b]Measured by numeracy subscore on the Test of Functional Health Literacy in Adults (TOFHLA); adequate = 38 or higher out of 50, limited = 37 or lower out of 50. HANDLS = Healthy Aging in Neighborhoods of Diversity across the Life Span; BMI = body mass index.

compared with participants with adequate health literacy and numeracy (Table 1). In addition, participants with limited health literacy were more likely to be male, uninsured, without a regular source of health care, and/or currently smoke cigarettes than were those with adequate health literacy. Participants with limited health numeracy had lower BMI than those with adequate health numeracy (Table 1). Within race groups, White individuals with limited health literacy were more likely to be current alcohol users and/or current cigarette smokers than were White persons with adequate health literacy (Supplemental Table 1). Black individuals with limited health numeracy were more likely to be food insecure and/or have diabetes than were Black with adequate health numeracy (Supplemental Table 1). Mean total DASH score was 2 (range = 0–7.5); only 6.9% of the sample were DASH accordant (score ≥4.5; Table 2).

Associations of Health Literacy and Numeracy With DASH

In unadjusted models, REALM (p = .001), but not TOFHLA, was positively associated with total DASH score with supplements in the overall sample (Table 3). In age- and sex-adjusted models, higher REALM continued to be associated with higher total DASH score with supplements in the overall sample (β = .009, 95% confidence interval [CI] = [.001, .016]). When educational attainment was added to Model 3, the association between REALM and total DASH with supplements was no longer statistically significant. In race-stratified analyses, the relationship of TOFHLA with total DASH score with supplements was statistically significant in Models 1 and 2 among White (β =.025, 95% CI = [.001, .049]) but not Black (β = −.003, 95% CI = [−.016, 0.010]) participants. These associations were no longer significant after educational attainment was added to the models. There were no significant associations between REALM or TOFHLA and DASH sodium scores (Table 3).

When analyzing the relationships between DASH scores calculated without supplements, results were largely similar to those calculated with supplements. Mean total DASH score without supplements was 1.8 (range = 0–7.5); only 5.4% of the sample were DASH accordant (score ≥4.5) without supplement data (Supplemental Table 2). Overall DASH accordance was significantly higher in Black individuals with adequate health literacy compared with Black individuals with limited health literacy (Supplemental Table 2). In adjusted models, REALM, but not TOFHLA, was associated with total DASH score (Supplemental Table 3). However, REALM was no longer associated with total DASH score once age and sex were included in the model. There were also no associations between REALM or TOFHLA with DASH sodium scores without supplements.

Discussion

Among this diverse sample of urban-dwelling hypertensive adults, we found that higher health literacy but not health numeracy was associated with higher total DASH accordance score, and educational attainment appeared to explain these

Table 2. DASH Accordance Measures by Health Literacy Status and Participant Race.

Characteristic	*N* for analysis	Overall	White			Black		
			Adequate health literacy ($N = 295$)	Limited health literacy ($N = 73$)	*p* value*	Adequate health literacy ($N = 429$)	Limited health literacy ($N = 276$)	*p* value*
Total DASH score[a] with supplements, mean (median, range)	1,073	2.0 (2, 0–7.5)	2.4 (2, 0–7.5)	2.0 (2, 0–7.5)	0.02	1.9 (1.5, 0–6.5)	1.7 (1.5, 0–6)	0.06
DASH sodium score[b] with supplements, mean (median, range)	1,073	0.1 (0, 0–1)	0.1 (0, 0–1)	0.1 (0, 0–1)	0.86	0.1 (0, 0–1)	0.1 (0, 0–1)	0.94
DASH accordance with supplements, *n* (%)	1,073	74 (6.9)	29 (9.8)	6 (8.2)	0.83	29 (6.8)	10 (3.6)	0.09

[a]DASH score calculated by indexing nutrient goals to total energy intake and summing all nutrient targets met (maximum score = 9). [b]DASH sodium score: 0 (*did not meet target*), 0.5 (*met intermediate sodium goal*), or 1 (*met DASH sodium goal*). DASH = Dietary Approaches to Stop Hypertension.
*Wilcoxon rank-sum test.

findings. Health numeracy was associated with total DASH score with supplements only among White participants. In our sample, limited health literacy and health numeracy were more prevalent among Black as compared with White adults. In analyses without the inclusion of supplements, Black individuals with adequate health literacy were more likely to be accordant with the DASH diet than Black individuals with limited health literacy.

This is among the first studies assessing the relationship between health literacy, health numeracy, and DASH diet accordance. A previous study did not find an association between health literacy and following a DASH-like diet, but could not control for education due to correlation with health literacy (Hutchison et al., 2014). In our study, education and health literacy were not highly correlated; therefore, education was included in our models. Past research has demonstrated the relationship between health literacy and diet quality as measured by healthy eating index (HEI) scores and sugar-sweetened beverage consumption, although education did not predict diet scores or beverage consumption (Zoellner et al., 2011). The relationship between health literacy and diet quality thus may vary depending upon which health literacy measures are used, as well as which particular aspects of diet quality are being analyzed. We did not find any associations between health literacy or numeracy with DASH sodium score. This is consistent with a previous analysis of the HANDLS cohort, which found no difference in sodium intake between participants living in poverty and those not living in poverty (Liu et al., 2017).

Our study builds upon prior work demonstrating low levels of DASH adherence among HANDLS participants (Crews et al., 2015; Liu et al., 2017) and a link between health literacy and nutrient-based diet quality, as measured by Nutrient Adequacy Ratio and Mean Adequacy Ratio based on food and dietary supplements, which was greater at higher education levels (Kuczmarski et al., 2016). Our findings are also consistent with the determination that health numeracy was not associated with diet quality (Kuczmarski et al., 2016).

Prior studies have noted that educational attainment is a determinant of diet quality; those who have a college education tend to have higher HEI; vegetable, fruit, and variety scores (McCabe-Sellers et al., 2007); as well as whole grains and calories from solid fats, alcoholic beverages, and added sugars (Hiza et al., 2013) than those in lower education groups. This could be because educational attainment may impact the ability to obtain and incorporate knowledge about nutrition guidelines into healthy dietary practices (Kennedy et al., 1999). However, social determinants of health and neighborhood effects on health are also important to consider. SES, including educational attainment and income, impacts one's ability to afford and acquire healthy foods, thus impacting diet quality. In addition, the neighborhood one lives in determines one's access to healthy foods; residents of census tracts that lack access to healthy foods are more likely to also have lower levels of educational attainment and income (Dutko et al., 2012), and those who live in neighborhoods with better access to healthy foods are more likely to have better diet quality (Larson et al., 2009). In addition, our study found that Black Americans with lower health numeracy were more likely to be food insecure; Black Americans with low SES are also more likely to live in neighborhoods that lack access to healthy foods (Block et al., 2004), all of which may further contribute to racial disparities in diet quality and hypertension.

Health literacy is a key factor in hypertension self-management. Investigators have noted that higher health literacy is associated with greater knowledge of hypertension (Du et al., 2018). Specifically, hypertensive patients with limited health literacy often do not know how dietary factors affect blood pressure (Williams et al., 1998). Health literacy may be indirectly related to self-care behaviors, such as physical activity, through pathways involving knowledge, self-efficacy, and health behavior, which would ultimately affect health status (Osborn et al., 2011). One study found that health numeracy

Table 3. Multivariable Linear Regression Models of Relation of REALM and TOFHLA Scores With DASH Total Accordance and Sodium Scores With Supplements, Overall and by Participant Race.

		Overall		*p* interaction for Predictor × Race	White		Black	
Model	Predictor	Coef. (*SE*)	*p* value		Coef. (*SE*)	*p* value	Coef. (*SE*)	*p* value
Total DASH with supplements								
Model 1	REALM	.013 (0)	.001	.338	.016 (.01)	.059	.007 (0)	.075
	TOFHLA	.008 (.01)	.178	.016	.029 (.01)	.019	−.003 (.01)	.637
Model 2	REALM	.009 (0)	.022	.324	.015 (.01)	.079	.007 (0)	.096
	TOFHLA	.005 (.01)	.411	.025	.025 (.01)	.041	−.003 (.01)	.647
Model 3	REALM	.004 (0)	.352	.462	.007 (.01)	.458	.003 (0)	.450
	TOFHLA	−.002 (.01)	.743	.109	.011 (.01)	.387	−.007 (.01)	.312
Model 4	REALM	.007 (.01)	.314	.250	.015 (.01)	.297	.002 (.01)	.840
	TOFHLA	−.003 (.01)	.749	.792	−.003 (.02)	.851	−.003 (.01)	.771
DASH sodium with supplements								
Model 1	REALM	.001 (0)	.371	.543	.001 (0)	.466	0 (0)	.819
	TOFHLA	0 (0)	.923	.466	.001 (0)	.595	−.001 (0)	.652
Model 2	REALM	0 (0)	.689	.534	.001 (0)	.496	0 (0)	.989
	TOFHLA	0 (0)	.831	.524	.001 (0)	.67	−.001 (0)	.559
Model 3	REALM	.001 (0)	.501	.532	.002 (0)	.380	0 (0)	.841
	TOFHLA	0 (0)	.891	.575	.001 (0)	.657	−.001 (0)	.613
Model 4	REALM	.002 (0)	.104	.899	.003 (0)	.269	.002 (0)	.189
	TOFHLA	.003 (0)	.171	.676	.006 (0)	.095	.002 (0)	.503

Note. Formula: DASH score calculated by indexing nutrient goals to total energy intake and summing all nutrient targets met (maximum score = 9). Model 1: Unadjusted (REALM or TOFHLA only). Model 2: Model 1 + Age, sex. Model 3: Model 2 + Education. Model 4: Model 3 + Income, poverty status, health insurance status, regular source of health care, food security, BMI, tobacco use, and alcohol use. REALM = Rapid Estimate of Adult Literacy in Medicine; TOFHLA = Test of Functional Health Literacy in Adults numeracy subscore; DASH = Dietary Approaches to Stop Hypertension; BMI = body mass index.

may be associated with health management, such as completeness of home blood pressure monitoring (Rao et al., 2015). In addition, health numeracy, when measured by nutrition label numeracy, was one of the strongest predictors of diet-related health behaviors (Nogueira et al., 2016). Thus, a focus on health literacy and health numeracy remains important for improving hypertension management.

Our study had limitations. First, the cross-sectional design does not enable us to discern the directionality of observed associations. Second, self-reported chronic conditions were included in the analyses, which may not reflect all participants who have chronic conditions as would be indicated through biological measures or documented by their health professional. However, we chose to use self-report here as it would reflect participants' knowledge of this diagnosis, which would be expected to potentially influence their dietary patterns. Third, we were unable to assess whether participants had received any advice from a health care professional to implement dietary changes to follow a DASH-like diet and whether this could have had any influence on the associations that were seen. Fourth, we were unable to include literacy in our models, which could have affected the associations observed. Fifth, the low level and limited range of overall DASH accordance in our sample may have hindered our ability to detect statistically significant differences across health literacy and health numeracy; however, our estimates of mean DASH scores were similar to national estimates (Mellen et al., 2008), despite HANDLS being inclusive of participants across a range of SES. Sixth, the REALM may not assess all aspects of health literacy, such as comprehension of printed material and information seeking (Dumenci et al., 2013), which may limit the generalizability of our findings. The strengths of our study include the sizable racially and socioeconomically diverse sample of adults; the assessment of DASH scores quantitatively using the Mellen formula (Mellen et al., 2008); the inclusion of dietary supplement data, particularly given their use being more common among people with higher literacy and educational attainment (Duffy et al., 2017); and the examination of health numeracy in addition to health literacy.

The implications of our findings are that, following the DASH diet, an important approach to treating hypertension, may not be fully accessible to people with limited health literacy or low educational attainment. Addressing this challenge depends upon both individual clinicians as well as health care and other organizations. The U.S. Department of Health and Human Services, in Healthy People 2030, defines organizational health literacy as "the degree to which organizations equitably enable individuals to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" (U.S. Department of Health and Human Services, 2021). This definition acknowledges that an individual's health literacy is contextual and that

producers of health information and services play an important role in improving health literacy (U.S. Department of Health and Human Services, 2021). Our study underscores that DASH diet information could likely be better delivered to people with hypertension who also have limited health literacy or low educational attainment. Clinicians can strengthen care management for such patients through the use of health communication tools such as the National Institutes of Health (NIH) Clear & Simple Guide, which was designed for those with limited health literacy (National Institutes of Health, 2021). The application of this and other tools in dietary interventions for people with hypertension, would be an important advance. Improving health communication with patients with limited health literacy, especially considering disparities in health literacy between Black Americans and White Americans, could contribute to efforts to reduce disparities in hypertension between these populations. In addition, policies that ensure the availability of and access to healthy foods in neighborhoods with high proportions of residents with low educational attainment could help to provide supportive food environments and reduce disparities in diet-sensitive health conditions such as hypertension.

Conclusion

In conclusion, we found that higher health literacy but not health numeracy was associated with higher accordance to a DASH-like diet as reflected by DASH score and educational attainment appeared to explain these findings. These findings highlight the important role of educational attainment in determining health outcomes; the influence of education on following a healthy diet may contribute to education's effect on life expectancy (Case & Deaton, 2021). Future research may investigate the exact nature of the relationship between education, health literacy, and dietary accordance or quality. Interventions to improve adherence to a blood pressure–lowering dietary pattern for hypertensive individuals may take into account their education level and health literacy to most effectively tailor the delivery of dietary recommendations. This may be critical in the effort to reduce disparities in hypertension and its associated complications.

Acknowledgments

The authors would like to thank the participants of the HANDLS study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Intramural Research Program of the National Institute on Aging, National Institutes of Health (NIH); (M.K.E. and A.B.Z.: ZIA-AG000513). This work was also supported by the Intramural Research Program of the National Institute on Drug Abuse, National Institutes of Health, and was conducted as part of the Postbaccalaureate Intramural Research Training Award fellowship. D.C.C. was supported, in part, by Grant K24 HL148181 from the National Heart, Lung and Blood Institute, NIH. None of the funders had a role in the design, analysis, or writing of this article.

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Supplemental Material

Supplemental material for this article is available online at https://journals.sagepub.com/home/heb.

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Supplemental Figure. Conceptualized Relation of Health Literacy and Numeracy with Self-Management of Hypertension, Including Dietary Modifications.