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DIETETIC PRACTICE PROJECTS

Literacy Contributes to Greater Higher Diet Quality in a Socioeconomically Diverse Urban Prospective Cohort

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Literacy influences dietary outcomes, such as food label comprehension and portion size estimation skills. This study evaluated the relationship of literacy and diet quality among Healthy Aging in Neighborhoods of Diversity across the Life Span study participants. Healthy Aging in Neighborhoods of Diversity across the Life Span is a prospective study of socioeconomically diverse urban African Americans and whites. Diet quality was measured by the Healthy Eating Index-2010 on the basis of 2 recalls, and literacy, the Wide Range Achievement Test—3rd edition reading scores. An independent and synergistic association of literacy and education with diet quality was found, emphasizing the need to consider both variables when counseling clients about nutrition.
Key words: *African Americans*, *diet*, *diet quality*, *education*, *literacy*

LITERACY, and its influence on many health and nutrition-related topics, is recognized as an area of greater importance in health care today.[1-5] Literacy is defined as "an individual's ability to read, write, and speak in English, compute and solve problems at levels

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of proficiency necessary to function on the job and in society, to achieve one's goals, and develop one's knowledge and potential."[6(p552)] Low literacy is associated with poor control of chronic conditions, risk of dementia, hospitalizations, and mortality.[7-10] As chronic disease rates increase, there is a distinct possibility that gains in life expectancy achieved over the last 2 decades could be eroded. Olshansky et al[11] reported that in 2008 US adults with less than 12 years of education had life expectancy not much better than adults in the 1950s and the 1960s. Unlike education, the relationship of literacy with health and longevity has not been extensively studied.[12-14] Literacy seems critical to advancing the health of the United States.

About 43% (~93 million) of US adults have only the necessary skills to perform simple and everyday literacy activities.[15] These poor literacy levels pose a concern in relation to diet quality. In fact, literacy affects various dietary outcomes, such as food label comprehension, portion size estimation skills, and acquisition of and trust in nutrition information sources.[16-18] Literacy may be the strongest overall factor influencing dietary quality. To our knowledge, only 1 study has directly examined the effect of literacy on diet quality. Using a nutrition literacy assessment, Zoellner et al[19] found that literacy significantly predicted food-based diet quality among 373 Lower Mississippi Delta adults, primarily low-income African American women.

The Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study is a prospective study designed and conducted by the National Institute on Aging to explore persistent health disparities among a fixed cohort of 3720 adults in Baltimore, Maryland.[20] Previous HANDLS findings have shown links between race and diet quality and education and diet quality.[21] In addition, literacy was a stronger predictor of cognitive functioning than education; therefore, among this population, literacy may be a strong predictor of diet quality.[22] The aim of this study was to evaluate the relationship of literacy and diet quality and to determine whether literacy was a stronger predictor of diet quality than race, income, or education.

METHODS

HANDLS study background

The HANDLS study was planned as a 20-year longitudinal study. Participants were drawn from 13 predetermined Baltimore neighborhoods, yielding representative distributions of individuals between 30 and 64 years of age who were African Americans and whites, men and women, and of lower (self-reported household income <125% of the 2004 Health and Human Services poverty guidelines; poverty income ratio, [PIR]) and higher (≥125% PIR) socioeconomic status (SES).[20] The heuristic study design is a factorial cross of 4 factors: age, sex, race, and SES with approximately equal numbers of subjects per factorial cell. There were 2 phases in the baseline HANDLS study, 2004-2009. The first phase was done in the participant's home and consisted of an interview that included questionnaires about the participant's health status, health service utilization, psychosocial factors, dietary recall, neighborhood characteristics, and demographics. The second phase was completed on mobile medical research vehicles located in the participant's neighborhood. Assessments included a medical history, physical examination, dietary recall, cognitive evaluation, psychophysiology assessments, physical performance, and laboratory measures. The study protocol was approved by human institutional review boards at MedStar Health Research Institute and the University of Delaware. All HANDLS participants provided written informed consent and were compensated monetarily.

Sample

The present sample consisted of 2111 individuals who completed 2 days of 24-hour dietary recalls. Participants who completed only the phase 1 recall (n = 1235) were excluded since literacy testing was performed during phase 2 along with the second dietary recall. A flow diagram of the household sampling of eligible participants for this study is presented in Supplemental Digital Content Appendix 1, available at (http://links.lww.com/TIN/A11). There were no statistical differences in the distributions of demographic data or energy and nutrient profiles[23] or in the distributions of total Healthy Eating Index (HEI)-2010 scores between participants who completed 1 or both days of dietary recall. Thus, the study sample was considered representative of the entire HANDLS baseline sample.

Dietary collection method

The United States Department of Agriculture Automated Multiple Pass Method, a computerized method, was used to collect both 24-hour dietary recalls.[24] Measurement aids such as measuring cups, spoons, ruler, and an illustrated food model booklet assisted participants in estimating accurate quantities of foods and beverages consumed. Both recalls were administered in-person by trained interviewers, 4 to 10 days apart. Dietary recalls were coded using Survey Net, matching foods consumed with 8-digit codes in the Food and Nutrient Database for Dietary Studies version 3.0.[25]

Healthy Eating Index—2010 calculation

The National Cancer Institute's Applied Research Web site provided the basic steps in calculating the HEI-2010 component and total scores and statistical code for 24-hour recalls (http://appliedresearch.cancer.gov/tools/hei/tools.html). Detailed description of the procedure used is available on the HANDLS Web site (http://handls.nih.gov/06Coll-dataDoc.htm). Total and component HEI-2010 scores were calculated for each recall day (day 1 and day 2) and then averaged to obtain the mean HEI-2010 total and component scores for both days combined.

Literacy measure

Literacy was assessed by trained examiners on the medical research vehicles, using the reading subtest of the Wide Range Achievement Test—3rd Edition (WRAT-3), a widely validated and used measurement of literacy.[26,27] The WRAT-3 Reading subtest measures participants' ability to recognize and name letters and words. The total WRAT-3 Reading score (total correctly pronounced letters + total correctly pronounced words) served as the literacy measurement. The total WRAT-3 Reading score was converted to grade-level equivalents for descriptive purposes.[26]

Statistical analysis

Descriptive analyses and group comparisons by sex and race were calculated for participants with complete data on sociodemographic variables, literacy, two 24-hour recalls, and education (Stata, version 13). One-way analysis of variance was used to compare continuous variables across race-sex groups. Post hoc analyses were adjusted for multiple testing by Bonferroni correction to examine race differences within sex and sex differences within each race. For categorical variables, χ^2 test was used within race group (comparing by sex) or within sex group (comparing by race). Group comparisons were made for sociodemographic, socioeconomic, and lifestyle factors as well as for literacy and HEI-2010 (total and components).

The main analyses, multiple ordinary least square regression, were performed to examine the independent associations of education and literacy with the HEI-2010 total score as well as the putative super-additive effects of those 2 variables on the HEI-2010 total score by inclusion of the education × literacy interaction term in the model. Education was centered at 12 years and literacy at 40.

Healthy Eating Index-2010 components were analyzed separately as dichotomies because they had nonnormal distributions. Logistic regressions compared the uppermost tertile with the combination of the middle and lowest tertiles (uppermost tertile vs middle + lowest tertile). Literacy was entered as the main exposure variable in separate logistic models with dichotomized HEI-2010 component scores as outcomes. Odds of better dietary quality on those components were estimated and compared across levels of exposure, controlling for education and the other covariates included in the model. Additional analyses examined interaction between literacy and education in predicting the odds of "better dietary quality" for each HEI-2010 component.

A type I error of 0.05 was used to determine statistical significance, including main and interaction effects in ordinary least square and logistic regression models. A 2-stage Heckman selection model was constructed to account for potential selection bias.[28] A probit model was conducted in which the main selection variable (ie, within final sample vs not, for those in the initial sample) was modeled against complete sociodemographic variables (ie, initial sample), namely, age, sex, race/ethnicity, and PIR. From this model, the conditional probability of being selected was predicted and an inverse mills ratio, a function of that probability, was computed and entered as a covariate into the main statistical models.[29] Based on the multiple ordinary least square and logistic regression models with interaction terms, predicted values of the HEI-2010 total score were plotted against levels of literacy, allowing slopes to vary across levels of education.[30]

RESULTS

Literacy scores and educational attainment of white adults were significantly greater than those of African American adults. More than 70% of the white men and women had literacy scores of high school level or greater, while the literacy of roughly 47% of the African American men and women was at a level of 8th grade or below (Figure 1). Within sex, there were significant race differences for each category of literacy ($P < .01$) (Figure 1). Except for females with greater than high school education, there were significant differences ($P < .01$) in educational attainment between whites and African Americans within sex (Figure 2).

Mean age of HANDLS study participants was approximately 48 years (Table 1). Smaller

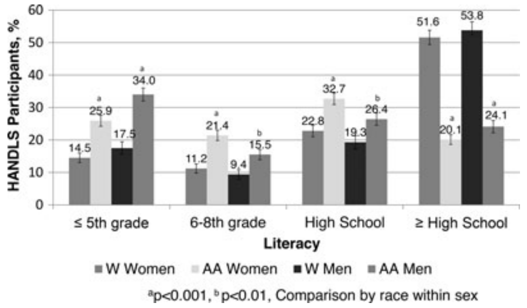

Figure 1. Literacy by race and sex for Healthy Aging in Neighborhoods of Diversity across the Life Span study participants. [a]$P < .001$, comparison by race within sex. [b]$P < .01$. HANDLS indicates Healthy Aging in Neighborhoods of Diversity across the Life Span.

proportions of African American adults were married ($P < .01$) and were poor (defined as self-reported household income <125% PIR) ($P < .001$). Smoking was more prevalent among African American men than among white men ($P < .001$). Among women, approximately 40% reported "currently smoking." The mean BMI of this population indicated an unhealthy body weight, using a BMI of 25.0 to 29.9 as overweight and BMI of 30 or more as obese.[31]

Unemployment ($P < .05$) and total energy intake ($P \leq .001$) were significantly higher in men than in women for both racial groups (see Table 1). Among African

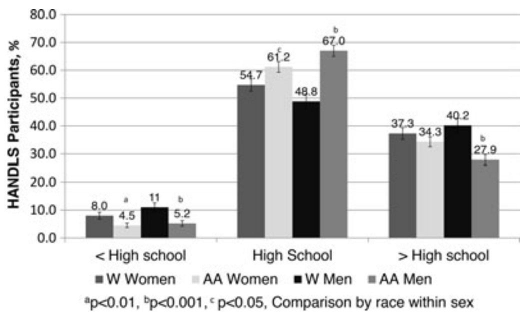

Figure 2. Education by race and literacy Healthy Aging in Neighborhoods of Diversity across the Life Span study participants. [a]$P < .01$. [b]$P < .001$, comparison by race within sex. [c]$P < .05$. HANDLS indicates Healthy Aging in Neighborhoods of Diversity across the Life Span.

Table 1. Characteristics of Healthy Aging in Neighborhoods of Diversity Across the Life Span Study Participants (N = 2111)[a]

	Women		Men		Sex Among Race Comparisons	
Characteristics	**White (n = 510)**	**African-American (n = 683)**	**White (n = 383)**	**African-American (n = 535)**	***P*, Whites**	***P*, AA**
Age, *M* (SE), y	47.7 (0.4)	47.9 (0.4)	48.1 (0.5)	47.7 (0.4)	1.00	1.00
Education, *M* (SE), y	12.9 (0.2)	12.3 (0.1)[b]	12.8 (0.2)	12.1 (0.1)[c]	1.00	1.00
Marital status, % married	37.5	21.5[c]	40.0	29.5[d]	.60	**.002**
Missing, %	4.1	4.3	3.1	5.6		
Employed last month, %	40.0	43.8[c]	52.7	49.2[c]	**<.001**	**.021**
Missing, %	25.5	10.8	23.8	13.3		
≥125 PIR, %	64.7	46.9[c]	73.4	51.2[c]	**.006**	.13
WRAT-3 score, *M* (SE)	44.3 (0.4)	39.8 (0.3)[c]	43.8 (0.5)	39.0 (0.4)[c]	1.00	.86
Energy, kcal, *M* (SE)	1760 (31)	1729 (31)	2,384 (55)	2,347 (47)	**<.001**	**<.001**
BMI, kg/m^2, *M* (SE)	30.8 (0.4)	31.5 (0.3)	28.9 (0.3)	27.4 (0.3)[b]	**.001**	**<.001**
Current smokers, %	42.8	41.0	44.9	56.3[c]	.14	**<.001**
Missing, %	4.5	6.3	2.1	4.7		

Abbreviations: AA, African Americans; BMI, body mass index; *M*, mean; PIR, poverty income ratio; SE, standard error; WRAT-3, Wide Range Achievement Test—version 3 test score.

[a]The bold values are significant at the level stated in table.

[b]$P < .05$.

[c]$P < .001$.

[d]$P < .01$.

Americans, more men smoked ($P < .001$) and were married ($P = .002$) than women. These characteristics did not differ in distribution by sex among whites. Among whites only, more men had a higher income than women ($P = .006$) (see Table 1). Irrespective of race, mean BMI was significantly higher in women than in men ($P \leq .001$).

There are no significant racial differences in total energy intake (see Table 1) or overall diet quality as measured by the HEI-2010 total score for either sex (see Table 2). However, significant racial differences were detected in selected food groups, as well as fatty acids. Specifically, mean intakes of the HEI-2010 whole fruit ($P < .01$), and dairy foods ($P < .001$) components of whites exceeded those of African Americans, among both men and women. With respect to HEI-2010 components for total protein foods, fatty acids, and refined grains, African American adults scored significantly higher than white adults. Another notable finding was that white men scored higher than African American men for total vegetables ($P < .01$) (see Table 2). When comparing HEI-2010 components by sex within racial groups (P values not shown in Table 2), only 2 significant findings were found: African American women had significantly higher total HEI-2010 ($P = .02$) and higher HEI-2010 total vegetable component scores ($P < .001$) than African American men.

Literacy and education were found to impact overall diet quality not only independently (model 1, Table 3) but also synergistically (model 2, Table 3; see Supplemental Digital Content Appendix 2, available at http://links.lww.com/TIN/A12). Based on model 1 (see Table 3), sex, race, age, and smoking were also significantly associated with overall diet quality, measured by the HEI-2010. Higher scores were associated with the following self-identified characteristics: being female, African American, older, and a nonsmoker.

The potential synergistic effects of education and literacy on the HEI-2010 components were also examined (see Supplemental Digital Content Appendix 3, available at http://links.lww.com/TIN/A13). The odds ratio (95% confidence interval) for the main effect of total vegetables was 1.013 (1.001-1.025; $P < .03$), suggesting that a 1-unit increase on the WRAT-3 score was associated on average with a 1.3% higher odds of being in the uppermost tertile of the total vegetable score (vs the lower 2 tertiles combined), among participants with average education of 12 years. Similarly, the odds ratio for whole grains component's main effect was 1.014 (1.002-1.026; $P < .02$) among participants with average education of 12 years, with a significant interaction between education and literacy indicating a synergistic effect between those 2 factors in increasing the likelihood of better dietary quality (uppermost tertile vs lower tertiles) in terms of whole grain consumption.

Moreover, education was associated with a higher likelihood of a better score on 5 HEI-2010 components among participants with a mean literacy score of 40, namely, total fruit, whole fruit, greens and beans, seafood and plant proteins ($P < .001$), and dairy ($P = .02$). The interaction between education and literacy in those models was nonsignificant, indicating homogeneity of effects across levels of literacy (see Supplemental Digital Content Appendix 3, available at http://links.lww.com/TIN/A13).

DISCUSSION

To our knowledge, this is the first study to document the independent and synergistic association of literacy and education with diet quality for a large, racially and socioeconomically diverse urban population. Although education and literacy levels are highly related, we expected that their effects on diet quality might differ. Literacy seems a better predictor of cognitive performance than years of education because it is a marker of quality of education.[22,32] On the contrary, education provides skills, such as vocabulary, numeracy, associative learning, and working memory,

Table 2. Healthy Eating Index—2010 Scores (*M* (SE)) for Healthy Aging in Neighborhoods of Diversity across the Life Span Study Participants Categorized by Sex and Race

HEI-2010 Components	Maximum Score	Upper Tertile Cutoff Score	Women		Men	
			White (n = 510)	African American (n = 683)	White (n = 383)	African American (n = 535)
Total vegetables	5	3.3	2.86 (0.06)	2.72 (0.05)	2.70 (0.07)	2.40 (0.06)[a]
Greens and beans	5	1.2	0.98 (0.06)	1.08 (0.06)	0.76 (0.06)	0.92 (0.06)
Total fruit	5	2.5	1.67 (0.08)	1.62 (0.06)	1.41 (0.08)	1.50 (0.07)
Whole fruit	5	1.6	1.53 (0.08)	1.10 (0.06)[b]	1.31 (0.09)	0.93 (0.06)[a]
Whole grains	10	1.8	2.04 (0.12)	1.82 (0.10)	1.84 (0.13)	1.49 (0.09)
Dairy	10	4.6	4.37 (0.13)	2.98 (0.09)[b]	4.56 (0.14)	2.95 (0.10)[b]
Total protein foods	5	4.4	4.00 (0.05)	4.38 (0.03)[b]	4.12 (0.05)	4.47 (0.03)[b]
Seafood and plant proteins	5	2.5	1.74 (0.07)	1.72 (0.06)	1.58 (0.08)	1.49 (0.07)
Fatty acids	10	6.3	4.35 (0.12)	5.65 (0.10)[b]	4.22 (0.13)	5.46 (0.11)[b]
Sodium	10	8.3	4.91 (0.14)	5.00 (0.1)1	4.74 (0.15)	5.11 (0.12)
Refined grains	10	7.8	6.00 (0.13)	6.46 (0.10)[c]	5.62 (0.15)	6.60 (0.11)[b]
Empty calories	20	11.2	8.66 (0.25)	9.01 (0.20)	8.62 (0.29)	8.32 (0.22)
Total score	100	46.4	43.11 (0.57)	43.54 (0.43)	41.48 (0.61)	41.64 (0.41)

Abbreviation: HEI, Healthy Eating Index.
[a] $P < .01$.
[b] $P < .001$.
[c] $P < .05$.

Table 3. Total 2010-Healthy Eating Index Score as Predicted by Literacy and Sociodemographic/Lifestyle Predictors: Multiple Ordinary Least Square Regression Models (n = 2111)[a]

Predictor	Model 1[b] β (SE)	Model 2[c] β (SE)
Sex (Men vs women)	− 1.33 (0.47)[d]	− 1.39 (0.47)[d]
Race (AA vs white)	+1.60 (0.48)[e]	+1.75 (0.49)[e]
PIR (≥ 125% vs <125%)	+0.71(0.49)	+0.70 (0.49)
Age, y	+0.15 (0.02)[e]	+0.15 (0.02)[e]
Education, y	+0.81 (0.08)[e]	+0.75 (0.09)[e]
WRAT-3 score, per 10 units	+0.78 (0.26)[d]	+0.80 (0.26)[d]
Current smokers		
Yes vs no	− 4.78 (0.49)[e]	− 4.73 (0.49)[e]
Missing vs no	− 1.60 (1.11)	− 1.65 (1.11)
WRAT-3 score (per 10 units) × education	. . .	+0.15 (0.08)[f]

Abbreviations: AA, African American; PIR, poverty income ratio; WRAT-3, Wide Range Achievement Test, version 3.
[a]Education was centered at 12 years and WRAT-3 score at 40. WRAT-3 score was also rescaled from 1-unit increase to 10-unit increase for better interpretation in both the main effect and interaction term. Model was additionally adjusted for the inverse mills ratio to correct potential selection bias.
[b]Model 1 includes all the main effects.
[c]Model 2 includes the main effects plus the interaction of literacy and education.
[d]$P < .01$.
[e]$P < .001$.
[f]$P < .05$.

that literacy does not capture.[33] Some investigators hypothesize that literacy mediates the effect of education on health outcomes.[34,35] The findings of this study demonstrated that the diets consumed by persons with both more years of education and a high literacy score were of better quality than the diets consumed by people with the same years of school but lower literacy scores.

Analyses of the HANDLS study data revealed that race, sex, age, and smoking, but not income, were associated with overall diet quality. These results were consistent with another analysis of HANDLS study dietary data that found education, sex, and race to be significant predictors of diet quality, as measured by the Nutrient Adequacy Ratio score for micronutrients.[21] Literacy was not included in that analyses. Wang and Chen[36] have shown with nationally representative data of US adults from the 1994-1996 Continuing Survey of Food Intakes by Individuals and the Diet and Health Knowledge Survey that diet quality was associated with SES defined by education and income. Adults with higher SES had better diet quality as measured by the HEI-2005.

An interesting finding was the inconsistent associations of education and literacy with the individual components of the HEI-2010. The significant interaction between education and literacy for whole grains might be explained by the fact that consumption of foods from the whole grain component requires an individual to understand the difference between a whole and refined grain product. To be able to accurately identify grain products, people would need to read nutrition labels and descriptions on packages and menus. Therefore, people who are educated and have better literacy should be able to discriminate between food items. In contrast, both education and literacy independently were significant for total vegetables. Fresh vegetables are not labeled; however, canned and frozen vegetables do have nutrition information on package labels, possibly explaining why both education and literacy are important.

Neither education nor literacy was associated with the fatty acids, sodium, empty calories, or total protein foods components. One potential explanation is that the HANDLS study participants may be consuming foods from these groups on the basis of taste preferences, cost, and/or convenience rather than health-associated properties.[37] In addition, sodium and fatty acids are associated with many processed foods, such as sandwiches and pizza, which are generally purchased ready-to-eat. At the time of data collection, the Patient Protection and Affordable Care Act of 2010[38] did not exist, thus the majority of food-related businesses were not providing information about the energy and nutrient content of the foods sold. This lack of nutrition knowledge may contribute to the consumption of foods from these components.

While mean energy intakes of this population are similar to those reported by a nationally representative US population examined in the What We Eat in America, National Health and Nutrition Examination Survey (WWEIA-NHANES), 2007-2008,[39] mean HEI-2010 scores are notably lower by approximately 10 points.[40] Lower scores may reflect differences in sociodemographic and lifestyle factors of the WWEIA-NHANES and HANDLS study populations. Compared with the WWEIA-NHANES sample, HANDLS participants had higher than national rate for unemployment (4.6% to 10% from 2004 to 2009[41]) and smoking (19.8% for adults in 2007[42]). Unlike national statistics, the HANDLS sample population had higher proportions of whites and African Americans with income less than 25% under the income specified for the poverty threshold in 2007.[43] Education attainment was similar to that reported in Current Population Reports, that is, more than 4 out of 5 adults aged 25 years and older had a high school diploma or equivalent.[44] It is apparent that there are groups within the United States in need of greater health-related behavior improvements.

This study has several strengths. First, it focused on a unique, understudied, relatively large African American and white urban population who are vulnerable to unhealthy eating practices and at higher risk of health disparities. Second, the HEI-2010 scores were based on dietary data collected from two 24-hour recalls, which represent typical intakes and provide valid intakes for normal and overweight individuals.[45-47]

As with any research, there are limitations. First, although 2 dietary recall interviews were administered, there is still potential for biased data due to underreporting. Second, the WRAT-3 word reading subtest does not account health literacy skills, which may display a stronger link to diet quality. The Test of Functional Health Literacy in Adults and the Rapid Estimate of Adult Literacy in Medicine along with numeracy assessment were administered in Wave 3 of the HANDLS study. Since literacy and health literacy are related but not identical concepts, it would be of interest to test the association of these assessments to diet quality when data become available. Finally, results describe an urban population that resided in Baltimore, Maryland. Although the findings cannot be generalized to a national population, independent demographic analyses found this population representative of populations from 14 US cities with similar population densities and racial distribution.[48]

In conclusion, to the best of our knowledge, this study is the first to report HEI-2010 scores for a sizable urban population of African American and white adults. Both education and literacy were significantly associated with diet quality among HANDLS study participants. These findings suggest that investigators should consider the inclusion of literacy as an SES marker in future nutrition research. This study also illustrates the need to consider both education and literacy when counseling individuals and groups about nutrition. For improved adherence to treatment and health outcomes, interpersonal communication and patient-centered interactions should match the patient's educational background and literacy skills.[49-53] Weiss[54] suggested that it is the health professionals' responsibility to bridge the literacy gap by changing how messages are communicated. He recommended all health professionals communicate in plain language rather than medical terms; focus on a minimal number of key messages; speak slowly; use teach-back (having people repeat instructions back to you); and be sure all written materials are easy to understand.

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