DIABETES TECHNOLOGY & THERAPEUTICS
Volume 13, Number 9, 2011

DOI: 10.1089/dia.2011.0070

Development and Validation of a Spanish Diabetes-Specific Numeracy Measure: DNT-15 Latino

Richard O. White III, M.D., M.Sc.,[1] Chandra Y. Osborn, Ph.D., M.P.H.,[2] Tebeb Gebretsadik, M.P.H.,[3] Sunil Kripalani, M.D., M.Sc.,[2] and Russell L. Rothman, M.D., M.P.P.[2]

Abstract

Background: Although deficits in health literacy and numeracy have been described among Latinos, the impact of low numeracy on diabetes outcomes has not been studied. Study objectives were (1) to establish the reliability and validity of a 15-item Spanish, diabetes-specific numeracy measure (Diabetes Numeracy Test [DNT]-15 Latino) and (2) to examine the relationship between diabetes-specific numeracy and diabetes-related outcomes among a sample of Latino adults with diabetes.

Methods: Data collection included patient demographics, health literacy, general numeracy, diabetes-specific numeracy, acculturation, self-efficacy, self-care behaviors, and most recent glycosylated hemoglobin (HbA1c).

Results: Participants ($n = 144$) were on average 47.8 years old (SD = 12.1). The majority were female (62%), uninsured (81%), and of Mexican nationality (78%) and reported low levels of acculturation (96%). The DNT-15 Latino had high internal reliability (Kruder–Richardson 20 = 0.78). The DNT-15 Latino demonstrated construct validity, correlating with measures of health literacy ($\rho = 0.291$), general numeracy ($\rho = 0.500$), education ($\rho = 0.361$), and income ($\rho = 0.270$) ($P < 0.001$ for each). The DNT-15 Latino was significantly associated with acculturation but unrelated to self-efficacy, self-care behaviors, insulin use, and HbA1c.

Conclusions: The DNT-15 Latino is a reliable and valid measure of diabetes-specific numeracy for Latino patients with diabetes; however, additional studies are needed to further explore the association between diabetes-specific numeracy and acculturation and their impact on diabetes-related outcomes for Latinos.

Introduction

According to the Agency for Healthcare Research and Quality, Latinos are a priority group in need of improved healthcare access and quality.[1] Latinos with diabetes often receive care that is suboptimal.[2] For example, compared with non-Latino whites, Latinos have a higher prevalence of type 2 diabetes (11.8% vs. 7.1%),[3] are less likely to receive timely recommended services (such as eye exams, foot exams, and glycosylated hemoglobin [HbA1c] measurement), and are more likely to experience hospital admission for lower-extremity amputations secondary to diabetes-related complications.[2] Caring for patients with diabetes is often a challenge in that self-care plays a major role in successful treatment (e.g., monitoring blood glucose levels, following specific dietary and exercise programs, and administering medications).

Health literacy is "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions"[4] and has been associated with the ability to perform diabetes self-care activities.[5–8] In a study of 400 English- and Spanish-speaking patients with diabetes, lower health literacy was associated with poorer glycemic control.[5] In 2003, the U.S. Department of Education conducted a study in which 66% of Latinos were found to have basic or below basic health literacy skills.[9] This high prevalence was based on a subsample of Latinos with *some* English proficiency; the prevalence may be even higher in the millions of Latinos residing in the United States who do not speak English.[10]

Quantitative literacy, also referred to as numeracy, is the ability to use and understand numbers in daily life.[8] Examples of specific numeracy skills relevant to diabetes care include the ability to accurately calculate and adjust insulin doses, count carbohydrates, calculate portion sizes from food labels, and understand number hierarchy when testing blood sugar. In general, low numeracy skills have been associated with difficulty understanding health information, less disease-specific knowledge, and difficulty performing self-management tasks,

[1]Department of Internal Medicine, Meharry Medical College, Nashville, Tennessee.
[2]Division of General Internal Medicine and Public Health and [3]Biostatistics, Vanderbilt University Medical Center, Nashville, Tennessee.
The scientific content of this study was presented in poster format at the Health Literacy Annual Research Conference in October 2009.

including understanding food labels,[8] estimating portion size,[11] and adhering to medications.[12] Cavanaugh et al.[13] found that low *diabetes-specific* numeracy was associated with poor adherence to self-care activities, lower diabetes management self-efficacy, and higher HbA1c in English-speaking patients with type 2 diabetes. Little is known, however, about the relationship between numeracy and diabetes-related outcomes in Latinos. In fact, to our knowledge, only two published studies in the broader medical literature have attempted to document numeracy skills in Latino patients.[14,15]

To better understand the role of numeracy in Latino patients with diabetes, we translated the Diabetes Numeracy Test (DNT)-15, an instrument designed to measure the array of numeracy skills necessary for successful diabetes management in English-speaking patients with diabetes, into the DNT-15 Latino. We then examined the psychometric properties of the DNT-15 Latino: specifically, internal consistency reliability and construct validity with measures of health literacy, general numeracy, education, and income. We also explored the relationship between diabetes-specific numeracy and measures of acculturation, self-efficacy, self-care behaviors, insulin use, and glycemic control.

Research Design and Methods

The DNT-15 Latino was developed based on the recently validated DNT.[16] The original DNT was designed for English-speaking patients and initially contained 43 items assessing numeracy skills applied to nutrition, exercise, glucose monitoring, oral medications, and insulin use. Items require respondents to perform addition and subtraction, understand fractions, divide, understand numerical hierarchy, and perform multistep calculations. A shortened, 15-item version of this instrument demonstrated strong psychometric properties while covering all the skills tested by the 43-item version and has been recommended for use among English-speaking patients with diabetes.[13,16,17] This shortened version of the DNT provided the content that was translated into the DNT-15 Latino.

The first step was an iterative translation and back-translation process for each of the 15 items of the English-version scale, excluding text contained within food labels, using input from bilingual members of the research team including a physician, a certified diabetes educator, and research staff of Latino heritage. During this process, we also conducted cognitive interviews with six Latino patients with type 2 diabetes as well as with two other healthcare providers who care for Latino patients with diabetes. For items in which the translation was unclear, we solicited suggestions for clarification and incorporated these suggestions into the translated scale. These steps established the readability and comprehension of each item, as well as the instrument's content (face) validity prior to administration. The final version of the DNT-15 Latino is available elsewhere (www.mc.vanderbilt.edu/diabetes/drtc/preventionandcontrol/tools.php).

Identification of participants and data collection

Patients were recruited from an adult internal medicine clinic affiliated with a community-based academic medical center and from two urban primary care clinics designated as federally qualified community health centers in Nashville, TN. All three centers serve a growing Latino population.[18] Eligible patients were 18–85 years old, self-identified as Hispanic/Latino(Latina) with spoken Spanish fluency, had corrected visual acuity $\leq 20/50$ as determined by a Rosenbaum pocket vision screening test, and did not have a history of psychosis or dementia. The Meharry Medical College Institutional Review Board approved the study protocol, and both federally qualified community health center clinics provided written agreements for participation. Written informed consent and HIPAA authorization to access medical records were obtained from each participant in Spanish prior to enrollment.

Recruitment and enrollment co-occurred with scheduled office visits at the participating sites. Trained bilingual research assistants conducted a 60–90-min private, semi-structured interview with each participant before or after their office visit. For patients with inadequate literacy according to the Spanish version of the Short Test of Functional Health Literacy in Adults (S-TOFHLA), the research assistant administered all measures verbally to promote patient understanding of the items and accuracy of their responses. Glycemic (HbA1c) and lipid control were collected with the Cholestech (Hayward, CA) GDX and LDX point-of-care devices for participants who did not have a recent HbA1c in the medical record <6 weeks prior to recruitment. All participants were compensated $20 for their participation.

All measures were administered in Spanish only because of the high prevalence of limited English proficiency in the study population. Sociodemographic data were collected from each participant, including age, gender, nationality, diabetes type, years since diagnosis, education level, income, insurance status, and insulin use. Body mass index was calculated using chart extracted weight and height measurements by dividing weight (kg) by the square of height (m^2).

As described above, the DNT-15 Latino is a scale that assesses an array of numeracy skills needed for successful diabetes management. Each item is scored as correct or incorrect, and no partial credit is given. There is no time limit for administration of the scale and participants are provided a calculator to use if necessary. Scores are reported as total percentage correct (0–100%).

The S-TOFHLA is a 36-item questionnaire that measures health literacy skills using two prose passages that utilize a modified Cloze method in a medical context.[19] S-TOFHLA scores of 0–16, 17–23, and >23 indicate inadequate, marginal, and adequate health literacy, respectively.

The Wide Range Arithmetic Test (WRAT-4) is the fourth version of a validated general numeracy measure that assesses overall computational math skill.[20] Scores are standardized by age and can be used to determine the math grade-level equivalent using the indexed charts found in the manual.

The Short Acculturation Scale for Hispanics is a 12-item measure of acculturation in the areas of language, media use, and social interactions.[21] This scale has been used with a variety of Latino subgroups, including Mexicans, Cubans, Puerto Ricans, Dominicans, and Central and South Americans.[21] Scores are summed across all 12 items, and the average is reported. Average Short Acculturation Scale for Hispanics scores that are greater than 3 identify individuals with higher levels of acculturation.[21]

The Perceived Diabetes Self-Management Scale is an eight-item measure of one's confidence in diabetes self-management.[22] Higher scores indicate greater confidence.

The Summary of Diabetes Self-Care Activities (SDSCA)[23] is a 14-item measure that assesses self-report to various self-care behaviors including diet, exercise, blood glucose testing, foot care, and medication use in the past week.

Participant characteristics were described using mean and SD values or median and interquartile range as appropriate for continuous variables and frequencies with percentiles for categorical variables. Internal consistency reliability of the DNT-15 Latino was evaluated with the Kruder–Richardson 20 formula, an appropriate test for dichotomous data. As no "gold standard" for diabetes-specific numeracy skills in Latinos exists, the construct validity of the DNT-15 Latino was ascertained by examining its association with other validated measures of health literacy, general numeracy, education, and income. Specifically, we expected that higher DNT-15 Latino scores would be associated with higher health literacy scores, higher general numeracy scores, higher educational attainment, and higher incomes. We also explored the relationships between DNT-15 Latino scores and acculturation, self-efficacy, self-care behaviors, insulin use, and glycemic control. Insulin use was included given the assumption that many patients on insulin are required to adjust their dose based on carbohydrate intake, which requires sufficient numeracy skills.

Statistical analysis

Spearman correlation coefficient (ρ) values were used to test bivariate relationships between DNT-15 Latino scores and the aforementioned variables except for insulin use, where a Wilcoxon rank sum test was performed. Bivariate analyses were performed with SPSS® version 18 (SPSS, Inc., Chicago, IL), whereas multivariate analyses were performed with R statistical software version 2.10.1.[24] The independent association of DNT-15 Latino scores with glycemic control was assessed using a multivariate linear regression analysis adjusted for age, gender, education, income and insurance status. HbA1c was log transformed to normalize residuals. Non-transformed HbA1c results are presented as results were consistent and for ease of interpretation of β coefficient.

Results

Between March 2008 and August 2009, 163 patients with diabetes were approached. Thirteen patients did not participate because of a lack of interest, lack of time, inability to sign the consent form, or having a diagnosis of dementia. Complete data are available on 144 (96%) of the 150 who agreed to participate (Table 1). Overall mean age was 47.8 ± 12.1 years. The majority were female, self-reported Mexican nationality, were uninsured, and had poor glycemic and lipid control. Adequate health literacy measured by the S-TOFHLA (>23) was observed for 64% of participants; however, only 3% demonstrated greater than 8th grade math skills according to the WRAT-4.

Average time to complete the DNT-15 Latino was 23 ± 10.2 min. Participants' overall performance was poor, with a mean score of 26% correct. Table 2 presents the sample performance on each item with the corresponding diabetes-specific skill(s) and numeracy skill(s) tested. More than half of the participants demonstrated consistent difficulty with tasks that required simple calculations such as addition, subtraction, integer multiplication, and recognition of numerical hierarchy. A vast majority of the participants had difficulty estimating portion size, calculating carbohydrate intake, extracting data from food labels, and performing multistep calculations. The internal reliability of the DNT-15 Latino was strong with a Kruder–Richardson 20 coefficient of 0.78.

To test the construct validity of our instrument, we used Spearman correlations to assess the bivariate relationship between DNT-15 Latino scores and each of the aforementioned variables that were part of our validation model (Table 3). Construct validation was met with correlations between the following: DNT-15 Latino and validated measures of health literacy (S-TOFHLA), $\rho = 0.29$, $P < 0.001$; general numeracy (WRAT-4), $\rho = 0.50$, $P < 0.001$; education level, $\rho = 0.36$, $P < 0.0001$; and income, $\rho = 0.27$, $P = 0.0012$. The DNT-15 Latino was also associated with acculturation level ($\rho = 0.28$, $P = 0.001$) but not related to self-efficacy ($\rho = -0.11$), self-care behaviors (diet, $\rho = 0.031$; exercise, $\rho = 0.023$; blood glucose monitoring, $\rho = 0.080$; and medication adherence, $\rho = -0.096$), glycemic control ($\rho = 0.064$), or insulin use (all $P > 0.05$).

Discussion

The DNT-15 Latino is a reliable and valid measure of diabetes-specific numeracy skills among adult Latino patients with type 2 diabetes. Of the four a priori hypotheses in our construct validation model, all four were significant and in the expected direction. Specifically, the DNT-15 Latino was strongly associated with valid measures of health literacy, general numeracy, education, and income. To our knowledge, the DNT-15 Latino is the first scale that measures diabetes-specific numeracy skills in Latino patients. Our findings further suggest that among Latinos with many socio-demographic challenges and diabetes, both general and diabetes-specific numeracy skills are often inadequate. This is consistent with Gerber et al.[15] and Ginde et al.,[14] who previously reported numeracy skills deficits among Latinos. However, unique to this study was the high prevalence of low numeracy skills even among patients with adequate health literacy. This suggests that in Latino patients with diabetes, numeracy skills should be considered irrespective of health literacy status and complements similar observations among English-speaking diabetes patients reported by Rothman et al.[8] and Cavanaugh et al.[13]

Our study also adds to the literature on acculturation and health among Latinos. To our knowledge this study is the first to find a positive association between diabetes-specific numeracy and level of acculturation. Acculturation has been defined as a process in which individuals adopt varying degrees of behaviors, knowledge, and beliefs from a dominant culture.[25] Many have explored the impact of acculturation on Latino health behaviors and outcomes in several contexts, including diabetes, with some studies reporting a protective effect, whereas others have demonstrated deleterious effects.[25] Our findings suggest that higher diabetes-specific numeracy skills are associated with higher levels of acculturation.

There are several possible reasons for the lack of significant association between the DNT-15 Latino and our measures of self-efficacy, self-care behaviors, insulin use, and glycemic control. First, and most importantly, patients performed poorly overall on the DNT-15 Latino, which may have resulted in a floor effect. This floor effect may have limited our ability to accurately identify relationships between the

Table 1. Patient Characteristics

	n[a]	*Value*[b]
Demographic variable		
Age (years)	149	47.8 ± 12.1
Gender	150	
Female		93 (62)
Nationality	150	
Mexico		117 (78)
El Salvador		12 (8)
Honduras		6 (4)
Puerto Rico		6 (4)
Guatemala		4 (3)
Peru		2 (1)
Colombia		1 (0.7)
Panama		1 (0.7)
Diabetes type	148	
Type 2		128 (87)
Unsure		15 (10)
Type 1		5 (3)
Time since diagnosis (years)	147	4.0 (2.0, 9.0)
Education	148	
< High school		83 (56)
Some high school		25 (17)
High school graduate		27 (18)
Some college or beyond		13 (9)
Household income	141	
< $10,000		65 (46)
$10,000–19,999		56 (40)
$20,000–39,999		20 (14)
Insurance status	149	
Uninsured		121 (81)
Insulin use	149	
Yes		41 (28)
Previously received diabetes education	146	
Yes		73 (50)
Clinical variables		
Current HbA1c (%)	147	8.1 ± 2.3
BMI (kg/m^2)	144	31 ± 7.2
LDL (mg/dL)	137	110 ± 38.3
Participant skills		
S-TOFHLA raw score[c]	149	24.1 ± 10.1
Health literacy based on S-TOFHLA	149	
Inadequate		32 (21)
Marginal		22 (15)
Adequate		95 (64)
WRAT-4		
Standard score	145	75.2 ± 9.5
Math grade equivalent	145	
4th grade or less		108 (72)
5th–7th grade		33 (22)
8th–12th grade		4 (3)
DNT-15 Latino (% correct)	149	26.4 ± 18.9
Time to complete DNT-15 Latino (min)	144	23.0 ± 10.2
Participant behaviors		
SASH average score	144	1.5 ± 0.60
Acculturation level	144	
Low		138 (96)
PDSMS (self-efficacy)[d]	142	22.8 ± 6.4
SDSCA (days)		
General Diet Score	146	3.5 (1.4, 5.0)
Exercise Score	147	2.0 (0.5, 3.5)
Blood Glucose Monitoring	147	1.5 (0.0, 5.5)
Foot Care	146	3.5 (1.8, 7.0)
Medication Adherence Score	147	7.0 (4.0, 7.0)

[a]*n* is the number of non-missing values.
[b]Mean ± SD, median (interquartile range), or *n* (%).
[c]Score range 0–36.
[d]Score range 0–40.
BMI, body mass index; DNT-15, Diabetes Numeracy Test-15; HbA1c, glycosylated hemoglobin; LDL, low-density lipoprotein; PDSMS, Perceived Diabetes Self-Management Scale; SASH, Short Acculturation Scale for Hispanics; SDSCA, Summary of Diabetes Self-Care Activities; S-TOFHLA, Short Test of Functional Health Literacy in Adults; WRAT-4, Wide Range Arithmetic Test, version 4.

DNT-15 Latino and these measures. Performance on our measure was in fact similar to the poor performance reported by Gerber et al.,[15] who independently translated and measured numeracy using five of the original DNT-15 items; their sample, albeit small, shared similar demographic characteristics with our sample. Thus, future studies could potentially overcome floor effects by targeting a more heterogeneous Latino population in terms of education and sociodemographic status and/or considering alterations and adjustments to the measure itself, both of which we are currently exploring. Second, although we assessed self-care activities using a validated instrument, the SDSCA, their measurement was fairly insensitive, with each consisting of a single item on the SDSCA. Third, the relatively low percentage of insulin users in our sample (28%) may have contributed to performance on the DNT-15 Latino in which seven out of 15 questions contained contextual references to insulin and may explain the observed absence of association between diabetes-specific numeracy and insulin use. Sample size might also have limited our ability to demonstrate significant relationships. Finally, our measure of glycemic control utilized two methods including chart extraction and point-of-care testing, which may have introduced important measurement discrepancies.

Several other limitations are present. First, although we enrolled from three clinics in our community, the convenience sample of patients in this study may not be representative of the broader Latino population, thus limiting the generalizability of our findings. Our cross-sectional study design also limits conclusions regarding the positive association between diabetes-specific numeracy and acculturation. Why this association did not additionally associate with improved self-efficacy, self-care behaviors, and glycemic control is also unclear. Similarly, one may argue that our decision to not translate the information presented in food labels in the DNT-15 Latino may serve as a confounding factor for participants, but we have attempted to simulate real life settings in which Spanish-speaking patients with diabetes are expected to self-manage. Further study with perhaps larger, more heterogeneous samples and prospective designs may shed additional light on the impact of numeracy and the acculturative process on diabetes care and outcomes for Latino patients. To that end, our measure may ultimately provide researchers, clinicians, and educators with useful information regarding the numeracy skills of their Latino diabetes patients that they can then use to tailor educational instructions surrounding self-care.

Table 2. Overall Diabetes Numeracy Test-15 Latino Performance by Question

Question number	*Percentage correct*	*Diabetes-specific skill*	*Numeracy skill(s) required*
1	3%	Calculate CHO using food label	Multiplication
2	21%	Calculate CHO using portion size data	Multiplication, fractions
3	11%	Calculate CHO using food label	Multiplication, fractions
4	59%	Exercise management	Addition, multiplication
5	60%	Recognize normal glucose range	Numerical hierarchy
6	49%	Calculate number of test strips needed for travel	Addition, multiplication
7	38%	Test strip management	Division, addition, time
8	25%	Oral medication and time management	Addition, time
9	35%	Insulin dosing using syringe with analog scale	Numerical hierarchy
10	24%	Insulin dosing using insulin:CHO ratios	Division
11	42%	Sliding scale insulin use	Numerical hierarchy
12	5%	CHO counting, multistep insulin management	Numerical hierarchy, division, addition
13	11%	CHO counting, multistep insulin management	Numerical hierarchy, division, addition
14	4%	Multistep insulin management	Multistep addition
15	8%	Multistep insulin management	Multistep addition

CHO, carbohydrates.

Overall, our study contributes positively to the growing number of studies focusing on health literacy and numeracy in diabetes care. We provide validation of a new Spanish instrument that measures the array of numeracy skills required for Latino patients with diabetes. This instrument may be used to evaluate the unique influence of diabetes-specific numeracy on diabetes outcomes. Finally, we have identified a positive association between diabetes-specific numeracy and acculturation and have begun to explore the role of numeracy on self-care behaviors and glycemic control in this vulnerable population. To better understand the role of health literacy and numeracy in diabetes education, we have developed a diabetes educational program culturally tailored to Latinos with limited health literacy and numeracy skills that accounts for low levels of acculturation. We are currently evaluating this program in a quasi-experimental pre–post design.

Table 3. Diabetes Numeracy Test-15 Latino Construct and Predictive Validation Model

Variable	ρ[a]	P *value*
S-TOFHLA	0.291	< 0.0001
WRAT-4	0.464	< 0.0001
Acculturation level	0.267	0.001
Education level	0.332	< 0.0001
Income	0.270	0.001
Insulin users	26.6 (13.3, 40.0)	0.133[b]
Insulin nonusers	20.0 (13.3,33.3)	
Self-efficacy	− 0.102	0.23
General diet	0.033	0.70
Exercise	0.021	0.79
Blood glucose monitoring	0.080	0.33
Foot care	0.056	0.50
Medication adherence	− 0.042	0.62
Glycemic control (HbA1c)	0.064	0.44
	β *coefficient*[c]	P *value*[c]
Glycemic control (HbA1c)	− 0.04 − 0.50, 0.43)[d]	0.88

[a]Spearman correlation coefficient.
[b]Wilcoxon rank sum test based on median Diabetes Numeracy Test-15 difference with (interquartile range) for insulin use.
[c]Multiple linear regression model adjusting for age, gender, education, income, and insurance status for an interquartile range difference of 20 Diabetes Numeracy Test score.
[d]95% confidence interval in parentheses.
HbA1c, glycosylated hemoglobin; S-TOFHLA, Short Test of Functional Health Literacy in Adults; WRAT-4, Wide Range Arithmetic Test, version 4.

Acknowledgments

R.O.W. led the primary data collection, performed the analysis of the data along with T.G., and was the primary author of the manuscript. R.O.W., C.Y.O., S.K., and R.L.R. provided health literacy and numeracy expertise, participated in the development of the DNT-15 Latino, and provided editorial input into the manuscript. S.K. and R.L.R. provided mentorship to R.O.W. All authors have read and approved the final manuscript. This research was funded with support from the Pfizer Fellowship in Health Literacy and Clear Health Communication and a Tennessee Department of Health Project Diabetes Implementation Grant. R.O.W. is supported by Meharry Medical College's Clinical Research Education and Career Development Program (NIH NCRR CRECD 1R25RR17577). C.Y.O. conducted this research with the support of a Diversity Supplement Award (NIDDK 3P60 DK020593-S302). R.L.R. is currently supported by an NIDDK Career Award (5K23 DK065294-05). S.K. was supported by an NHLBI Career Award (K23 HL077597). Support for data capture and analysis was provided by REDCap (NCRR/NIH UL1 RR024975). The authors would also like to acknowledge research assistants Mrs. Ana Murto, Miss Patricia Paez, and Dr. Khalil Harbi at Meharry Medical College for their contribution to patient recruitment and data collection and Mary Bufwack, Ph.D., CEO at United Neighborhood Health Services, for access to their clinics.

Author Disclosure Statement

No competing financial interests exist.

References

1. Smedley BD, Stith AY, Nelson AR, eds.: Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Washington, DC: National Academies Press, 2003.

2. 2009 National Healthcare Disparities Report. Rockville, MD: Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services, 2010.
3. Centers for Disease Control and Prevention: National Diabetes Fact Sheet: National Estimates and General Information on Diabetes and Prediabetes in the United States, 2011. Atlanta: Centers for Disease Control and Prevention, 2011.
4. Nielsen-Bohlman L, Panzer AM, Kindig DA, eds.: Health Literacy: A Prescription to End Confusion. Washington, DC: National Academies Press, 2004.
5. Schillinger D, Grumbach K, Piette J, Wang F, Osmond D, Daher C, Palacios J, Sullivan GD, Bindman AB: Association of health literacy with diabetes outcomes. JAMA 2002;288:475–482.
6. Rothman RL, DeWalt DA, Malone R, Bryant B, Shintani A, Crigler B, Weinberger M, Pignone M: Influence of patient literacy on the effectiveness of a primary care-based diabetes disease management program. JAMA 2004;292:1711–1716.
7. Rothman R, Malone R, Bryant B, Dewalt D, Pignone M: Health literacy and diabetic control. JAMA 2002;288:2687–2688.
8. Rothman RL, Housam R, Weiss H, Davis D, Gregory R, Gebretsadik T, Shintani A, Elasy TA: Patient understanding of food labels: the role of literacy and numeracy. Am J Prev Med 2006;31:391–398.
9. Kutner MA, Greenberg E, Jin Y, Paulsen C: The Health Literacy of America's Adults: Results from the 2003 National Assessment of Adult Literacy. Washington, DC: National Center for Education Statistics, U.S. Department of Education, 2006.
10. Shin HB, Bruno R: Language Use and English-Speaking Ability: 2000. 2003. www.census.gov/prod/2003pubs/c2kbr-29.pdf (accessed May 31, 2001).
11. Huizinga MM, Carlisle AJ, Cavanaugh KL, Davis DL, Gregory RP, Schlundt DG, Rothman RL: Literacy, numeracy, and portion-size estimation skills. Am J Prev Med 2009;36: 324–328.
12. Waldrop-Valverde D, Osborn CY, Rodriguez A, Rothman RL, Kumar M, Jones DL: Numeracy skills explain racial differences in HIV medication management. AIDS Behav 2009;14:799–806.
13. Cavanaugh K, Huizinga MM, Wallston KA, Gebretsadik T, Shintani A, Davis D, Gregory RP, Fuchs L, Malone R, Cherrington A, Pignone M, DeWalt DA, Elasy TA, Rothman RL: Association of numeracy and diabetes control. Ann Intern Med 2008;148:737–746.
14. Ginde AA, Clark S, Goldstein JN, Camargo CA Jr: Demographic disparities in numeracy among emergency department patients: evidence from two multicenter studies. Patient Educ Couns 2008;72:350–356.
15. Gerber BS, Cano AI, Caceres ML, Smith DE, Wilken LA, Michaud JB, Ruggiero LA, Sharp LK: A pharmacist and health promoter team to improve medication adherence among Latinos with diabetes. Ann Pharmacother 2010;44:70–79.
16. Huizinga MM, Elasy TA, Wallston KA, Cavanaugh K, Davis D, Gregory RP, Fuchs LS, Malone R, Cherrington A, Dewalt DA, Buse J, Pignone M, Rothman RL: Development and validation of the Diabetes Numeracy Test (DNT). BMC Health Serv Res 2008;8:96.
17. Cavanaugh K, Wallston KA, Gebretsadik T, Shintani A, Huizinga MM, Davis D, Gregory RP, Malone R, Pignone M, Dewalt D, Elasy TA, Rothman RL: Addressing literacy and numeracy to improve diabetes care: two randomized controlled trials. Diabetes Care 2009;32:2149–2155.
18. Mendoza M, Petersen MC: New Latino immigration to Tennessee: practicing culturally sensitive health care. Tenn Med 2000;93:371–376.
19. Baker DW, Williams MV, Parker RM, Gazmararian JA, Nurss J: Development of a brief test to measure functional health literacy. Patient Educ Couns 1999;38:33–42.
20. Wilkinson GS, Robertson GJ; Psychological Assessment Resources Inc.: WRAT 4: Wide Range Achievement Test; Professional Manual. Lutz, FL: Psychological Assessment Resources Inc., 2006.
21. Marín G, Sabogal F, VanOss Marín B, Otero-Sabogal R, Perez-Stable EJ: Development of a short acculturation scale for Hispanics. Hispanic J Behav Sci 1987;9:183–205.
22. Wallston KA, Rothman RL, Cherrington A: Psychometric properties of the Perceived Diabetes Self-Management Scale (PDSMS). J Behav Med 2007;30:395–401.
23. Toobert DJ, Hampson SE, Glasgow RE: The summary of diabetes self-care activities measure: results from 7 studies and a revised scale. Diabetes Care 2000;23:943–950.
24. Team RDC: R: A Language and Environment for Statistical Computing, Reference Index Version 2.10.1. Vienna: R Foundation for Statistical Computing, 2005.
25. Lara M, Gamboa C, Kahramanian MI, Morales LS, Bautista DE: Acculturation and Latino health in the United States: a review of the literature and its sociopolitical context. Annu Rev Public Health 2005;26:367–397.

Address correspondence to:
Richard O. White III, M.D., M.Sc.
Department of Internal Medicine
Meharry Medical College
1005 Dr. D.B. Todd Jr. Boulevard
Nashville, TN 37208

E-mail: rwhite@mmc.edu