Associations Between Health Literacy, Diabetes Knowledge, Self-Care Behaviors, and Glycemic Control in a Low Income Population with Type 2 Diabetes

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Abstract

Objective: This study assessed associations among health literacy, diabetes knowledge, self-care, and glycemic control in a low income, predominately minority population with type 2 diabetes.

Methods: One hundred twenty-five adults with diabetes were recruited from a primary care clinic. Subjects completed validated surveys to measure health literacy, diabetes knowledge, and self-care (medication adherence, diet, exercise, blood sugar testing, and foot care). Hemoglobin A1c values were extracted from the medical record. Spearman's correlation and multiple linear regression were used to assess the relationship among health literacy, diabetes knowledge, self-care, and glycemic control controlling for covariates.

Results: Cronbach's α was 0.95 for the Revised Rapid Estimate of Adult Literacy in Medicine. The majority of the sample was <65 years old (50.7%), female (72.5%), and African American (71.4%), had less than a high school education (68.2%) and a household income <\$15,000 (64.2%), and reported their health status as worse than last year (73.9%). In adjusted models that examined the associations among health literacy, diabetes knowledge, medication adherence, and self-care, health literacy was only significantly associated with diabetes knowledge ($\beta = 0.55$; 95% confidence interval [CI] 0.29, 0.82). In the final adjusted model for independent factors associated with glycemic control, both diabetes knowledge ($\beta = 0.12$; 95% CI 0.01, 0.23) and perceived health status ($\beta = 1.14$; 95% CI 0.13, 2.16) were significantly associated with glycemic control, whereas health literacy was not associated with glycemic control ($\beta = -0.03$; 95% CI -0.19 , 0.13).

Conclusions: Diabetes knowledge and perceived health status are the most important factors associated with glycemic control in this population. Health literacy appears to exert its influence through diabetes knowledge and is not directly related to self-care or medication adherence.

Introduction

DIABETES MELLITUS IS APPROACHING epidemic proportions worldwide.¹ In the United States alone, an estimated 24 million people have diabetes² with a projected prevalence of 48 million by 2050.³ Diabetes is the seventh leading cause of death in the United States and likely to be underreported as a cause of death.^{3,4} Diabetes also imposes significant economic burdens with medical expenditures attributable to hospitalizations, medications, outpatient visits, and treatment of chronic complications.⁵ People with diabetes, on average, have medical costs that are 2.3 times higher than people without the disease.⁵ As the prevalence of diabetes continues to increase, it is estimated that the total cost of diabetes will exceed \$174 billion.⁵

A primary measure of glycemic control is hemoglobin A1c (HbA1c).⁶ Among patients with diabetes, lower HbA1c levels have been associated with decreased mortality⁷⁻⁹ and fewer complications.¹⁰⁻¹⁴ Research suggests that performance of self-care behaviors,¹⁵⁻²¹ increased diabetes knowledge,²²⁻²⁴ and greater medication adherence²⁵⁻²⁸ are associated with improved glycemic control.

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."²⁹ Recent studies suggest that health literacy plays a significant role in self-care,³⁰⁻³² medication adherence,³³ and clinical outcomes.³⁴⁻³⁸ Limited health literacy is common among individuals with diabetes^{31,35,37} and has been associated with poor diabetes knowledge,³¹

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fewer self-care behaviors,^{31,37} more self-reported complications,^{35,39} and worse glycemic control.³⁵⁻³⁸ However, evidence of the impact of health literacy on glycemic control has been mixed.^{31,35-40} More importantly, few studies have assessed the relationship between health literacy and glycemic control in a low income, predominately minority population. In addition, few studies have assessed the independent associations between health literacy and glycemic control while controlling for sociodemographic factors, diabetes knowledge, and self-care behaviors.

The purpose of this study was to assess the independent associations among health literacy, diabetes knowledge, self-care behaviors (medication adherence, diet, exercise, blood sugar testing, and foot care), and glycemic control to determine the independent contribution of health literacy to overall glycemic control in a low income, predominately minority population after adjusting for these factors. Based on prior literature,^{31,33,37,41} we hypothesized that health literacy would be independently associated with diabetes self-care and diabetes knowledge but not glycemic control in this population.

Subjects and Methods

Sample

We recruited consecutive patients diagnosed with type 2 diabetes mellitus (T2DM) and scheduled appointments at the Medical University of South Carolina Internal Medicine Clinic, Charleston, SC. The institutional review board at Medical University of South Carolina approved all procedures prior to study enrollment. Eligible patients were clinic patients, 18 years of age or older, with a diagnosis of T2DM in the medical record and a clinic appointment between June and August 2008. Patients were ineligible if they did not speak English or if the research assistants determined (by interaction or chart documentation) they were too ill or cognitively impaired to participate.

Data and procedure

Research assistants reviewed the electronic clinic roster to identify eligible patients. Eligible patients were approached in the clinic waiting room and provided a description of the study. Those interested and eligible were consented and taken to a private area in the clinic to complete the study instruments. Participants completed the assessment before or after their scheduled clinic appointments, depending on clinic flow. One hundred twenty-five subjects were consented and completed the study.

We collected data on self-reported age, sex, race/ethnicity, education, household income, and perceived health status. Additional measures included validated surveys of health literacy, diabetes knowledge, medication adherence, and diabetes self-care behavior. HbA1c values were extracted from the electronic medical records.

Demographic variables

Age was assessed as a continuous variable. Race/ethnicity was categorized as white and black because none of the participants was of Hispanic or other racial origin. Two levels of education were created: less than or equal to high school graduate and more than high school graduate. Personal income was categorized as $\leq \$15,000$, and $\$15,000+$. Health

status was based on the individual's current opinion of his or her health in comparison to 12 months previously (better, same, or worse than 12 months ago). For this analysis, perceived health status was categorized as better/same and worse.

Health literacy

We assessed literacy by using the Revised Rapid Estimate of Adult Literacy in Medicine (REALM-R), an eight-item instrument designed to rapidly screen patients for potential health literacy problems. The REALM-R has been previously correlated with the Wide Range Achievement Test Revised (0.64) and demonstrated a Cronbach's α of 0.91.⁴² The REALM-R is scored on a scale of 0 to 8 and asks patients to read a series of eight medical words, and a correct response is given for each correct pronunciation. Scores of 6 or less correspond to a grade 6 reading level and identify patients at risk for poor health literacy.⁴²

Diabetes knowledge

Diabetes knowledge was assessed with the Diabetes Knowledge Questionnaire (DKQ),⁴³ which elicits information about the respondent's understanding of the cause of diabetes, types of diabetes, self-management skills, and complications of diabetes. Response options are "yes," "no," or "don't know." The final score was based on the percentage of correct scores, with a maximal possible score of 100.⁴³

Medication adherence

The Morisky adherence score,⁴⁴ a commonly used self-report tool, was used to assess medication adherence. It has good reliability and validity.^{44,45} This scale asks patients to respond "yes" or "no" to a set of four questions. A positive response to any question indicates a problem with adherence with a total possible score of 4; higher values indicate poorer adherence.

Diabetes self-care behavior

Self-care behavior was assessed with the 11-item Summary of Diabetes Self-Care Activities scale,⁴⁶ which measures frequency of self-care activity in the last 7 days for five aspects of the diabetes regimen: general diet (followed healthful diet), specific diet (ate fruits/low fat diet), foot care, blood glucose testing, exercise, and cigarette smoking. For this analysis, general diet, foot care, blood glucose testing and exercise were used.

Glycemic control

Patients' most recent HbA1c value was extracted from the medical record and served as a measure of glycemic control.

Statistical analyses

We performed five sets of analyses. First, we ran a confirmatory factor analysis to determine the factor structure of the REALM-R and calculated a Cronbach's α for the REALM-R to establish its internal consistency in our study population. Second, we compared sample demographics using χ^2 statistics for categorical variables and t test or one-way analysis of variance for continuous variables. Third, we used Spearman's

correlation to test the association among health literacy, diabetes knowledge, and self-care behaviors (medication adherence, diet, physical activity, blood sugar testing, and foot care). Fourth, we ran multiple regression models to assess the independent associations between health literacy and diabetes knowledge, as well as self-care behaviors (medication adherence, diet, physical activity, blood sugar testing, and foot care) controlling for covariates. For each regression model, diabetes knowledge or self-care behaviors (medication adherence, diet, physical activity, blood sugar testing, and foot care) were the dependent variables, health literacy was the primary independent variable, and age, sex, race/ethnicity, education, income, and health status were included in the model as covariates. Fifth, we ran a multiple regression model to assess the independent effect of health literacy on glycemic control controlling for sociodemographic characteristics, diabetes knowledge, and self-care behaviors. In this model, HbA1c was the dependent variable, health literacy was the primary independent variable, and sociodemographic variables, diabetes knowledge, and self-care behaviors were entered into the model as covariates. All analyses were performed with STATA version 10 (Stata Corp. LP, College Station, TX), and a two-tailed α of 0.05 was used to assess for significance. Variables were included in the model based on clinical relevance.

Results

Factor analysis, internal consistency, and reliability

The principal component analysis yielded an eight-item REALM-R with one factor having a measured eigenvalue of 6.17 that accounted for 77% of the variance. Factor loadings ranged from 0.778 to 0.902. All individual items correlated at greater than 0.75 with this factor.⁴⁷

Test of internal consistency for the eight-item REALM-R revealed a Cronbach's α of 0.95. The item-test correlation of the eight-item REALM-R ranged from 0.779 to 0.909, and the item analysis showed that α would not be meaningfully improved by dropping any one item from the scale.

Sample characteristics

A total of 125 men and women with T2DM completed all measures noted above. As shown in Table 1, the majority of the sample was <65 years old (50.7%), female (72.5%), and African American (71.4%), had less than a high school education (68.2%) and a household income of <\$15,000 (64.2%), and reported their health status as worse than last year (73.9%). In our sample, the unadjusted mean scores ($\pm$ SD) for health literacy, diabetes knowledge, and medication adherence were 6.1 ± 0.3 (REALM-R), 15.3 ± 0.4 (DKQ), and 0.9 ± 0.1 (Morisky). Among the four self-care behaviors, unadjusted mean scores ($\pm$ SD) were as follows: general diet (4.6 ± 0.2), exercise (2.7 ± 0.2), blood sugar monitoring (4.7 ± 0.2), and foot care (5.2 ± 0.2). Baseline HbA1c ($\pm$ SD) was $7.6 \pm 0.2\%$.

Health literacy, diabetes knowledge, medication adherence, and diabetes self-care

Table 2 shows correlations for health literacy, diabetes knowledge, medication adherence, and diabetes self-care. Health literacy was significantly related to diabetes knowl-

TABLE 1. SAMPLE CHARACTERISTICS

Characteristics (n = 125)	Mean $\pm$ SD or %
Age categories	
<65 years	50.7
65+ years	49.3
Females	72.5
Race	
Black	71.4
White	28.6
Education categories	
$\leq$ High school graduate	68.2
>High school graduate	31.8
Income categories	
$\leq$ \$15,000	64.2
\$15,000+	35.8
Health status	
Better or same as last year	26.1
Worse than last year	73.9
Health literacy	
Realm-R (mean number correct)	6.1 ± 0.3
Diabetes knowledge	
DKQ (mean number correct)	15.3 ± 0.4
Medication adherence	
Morisky score (mean score)	0.9 ± 0.1
Diabetes self-care	
General diet	4.6 ± 0.2
Exercise	2.7 ± 0.2
Blood sugar monitoring	4.7 ± 0.2
Foot care	5.2 ± 0.2
Mean HbA1c (%)	7.6 ± 0.2

DKQ, Diabetes Knowledge Questionnaire; HbA1c, hemoglobin A1c; REALM-R, Revised Rapid Estimate of Adult Literacy in Medicine.

edge ($r = 0.446$, $P < 0.001$) but, however, was not significantly related to medication adherence or diabetes self-care (general diet, exercise, blood sugar testing, and foot care).

Table 3 shows associations among health literacy, diabetes knowledge, medication adherence, and diabetes self-care after adjusting for relevant sociodemographic covariates. In comparisons between health literacy and other variables, health literacy was only significantly associated with diabetes knowledge ($\beta = 0.55$; 95% confidence interval [CI] 0.29, 0.82).

In comparisons between demographic characteristics and other variables, age was only associated with diet ($\beta = 0.97$; 95% CI 0.17, 1.77) and foot care ($\beta = 1.52$; 95% CI 0.62, 2.42).

TABLE 2. CORRELATIONS FOR HEALTH LITERACY, DIABETES KNOWLEDGE, MEDICATION ADHERENCE, DIET, EXERCISE, BLOOD SUGAR TESTING, AND FOOT CARE

	REALM-R	P value
Diabetes knowledge	0.446	<0.001*
Morisky score (medication adherence)	0.025	0.784
General diet	0.108	0.225
Exercise	0.079	0.373
Blood sugar testing	0.023	0.796
Foot care	0.068	0.444

Correlations are Spearman correlations.

*Significant correlations at $P < 0.05$.

REALM-R, Revised Rapid Estimate of Adult Literacy in Medicine.

TABLE 3. ASSOCIATIONS AMONG HEALTH LITERACY, OTHER DEMOGRAPHIC VARIABLES, DIABETES KNOWLEDGE, MEDICATION ADHERENCE, AND SELF-CARE

Variable	DKQ	Morisky score	Diet	Exercise	BST	Foot care
Age (<65 vs. 65+ years)	0.41 (-1.12, 1.93)	-0.31 (-0.71, 0.09)	0.97 (0.17, 1.77)*	-0.43 (-1.37, 0.51)	0.73 (-0.20, 1.64)	1.52 (0.62, 2.42)*
Sex	0.49 (-1.30, 2.29)	0.03 (-0.43, 0.49)	0.24 (-0.68, 1.16)	-1.04 (-2.13, 0.04)	0.13 (-0.93, 1.20)	-0.25 (-1.29, 0.79)
Race	-2.04 (-3.71, -0.37)*	-0.09 (-0.53, 0.35)	0.38 (-0.50, 1.27)	0.27 (-0.78, 1.31)	0.27 (-0.76, 1.29)	0.02 (-0.98, 1.01)
Education	0.88 (-0.91, 2.66)	0.02 (-0.44, 0.49)	0.86 (-0.08, 1.79)	0.50 (-0.61, 1.60)	0.44 (-0.64, 1.53)	0.70 (-0.35, 1.76)
Income	0.93 (-0.78, 2.65)	-0.04 (-0.05, 0.42)	-0.15 (-1.07, 0.76)	0.43 (-0.65, 1.51)	-0.57 (-1.62, 0.49)	-0.28 (-1.31, 0.75)
Health Status	0.04 (-1.67, 1.74)	0.59 (0.15, 1.03)*	-0.39 (-1.27, 0.48)	-0.78 (-1.11, 0.96)	-0.69 (-1.71, 0.32)	-0.11 (-1.10, 0.88)
RealM-R	0.55 (0.29, 0.82)*	-0.17 (-0.09, 0.05)	0.09 (-0.05, 0.23)	-0.06 (-0.22, 0.11)	0.01 (-0.15, 0.17)	0.03 (-0.13, 0.19)

Associations were by multiple linear regression models with knowledge, adherence, diet, exercise, blood sugar testing (BST), and foot care as dependent variables and health literacy as the primary independent variable with age, sex, race, education, income, and health status as covariates. Data are mean (95% confidence interval) values.

*Significant associations at $P < 0.05$.

DKQ, Diabetes Knowledge Questionnaire.

Race was only associated with diabetes knowledge ($\beta = -2.04$; 95% CI $-3.71, -0.37$), and perceived health status was associated with medication adherence ($\beta = 0.59$; 95% CI $0.15, 1.03$) and not the other variables. Gender, education, and income status were not associated with the other variables.

Table 4 presents the independent factors associated with glycemic control. Health literacy was not associated with glycemic control. However, both diabetes knowledge ($\beta = 0.12$; 95% CI $0.01, 0.23$) and perceived health status ($\beta = 1.14$; 95% CI $0.13, 2.16$) were significantly associated with glycemic control. No other factor was significantly related to glycemic control.

Discussion

Consistent with our hypothesis, health literacy was independently associated with diabetes knowledge but was not associated with glycemic control in a low income, predominately minority population. Other studies have also found similar associations between limited health literacy and poorer disease knowledge.³⁰⁻³² After adjustment for pertinent covariates, this relationship remained statistically significant, and when included in the same model (Table 4), increased diabetes knowledge was associated with significantly lower HbA1c levels, whereas while no significant relationship was observed between health literacy and HbA1c. These findings suggest that health literacy does not directly influence glycemic control but probably influences glycemic control through diabetes knowledge. We also found perceived health status was significantly associated with glycemic control, which suggests that, along with diabetes knowledge, health status influences glycemic control among indigent adults with type 2 diabetes.

In contrast to our hypothesis, health literacy was not associated with diabetes self-care. Although it is possible that limited health literacy and subsequent poorer diabetes knowledge may impact self-care behavior, we did not observe

TABLE 4. INDEPENDENT FACTORS ASSOCIATED WITH GLYCEMIC CONTROL

Variable	Coefficient	95% CI
REALM-R	-0.03	(-0.19, 0.13)
DKQ	0.12*	(0.01, 0.23)
Morisky score	-0.11	(-0.56, 0.35)
General diet	-0.50	(-0.28, 0.18)
Exercise	-0.03	(-0.23, 0.16)
Blood sugar test	0.08	(-0.11, 0.28)
Foot care	-0.05	(-0.27, 0.18)
Age	-0.85	(-1.81, 0.12)
Sex	-0.78	(-1.78, 0.23)
Race	0.74	(-0.24, 1.73)
Education	-0.72	(-1.81, 0.37)
Income	-0.24	(-1.26, 0.77)
Health status	1.14*	(0.13, 2.16)

Multiple linear regression models with glycemic control as a dependent variable and Revised Rapid Estimate of Adult Literacy in Medicine (REALM-R) as the primary independent variable with knowledge, adherence, self-care, and other demographic variables as covariates.

*Significant correlations at $P < 0.05$.

CI, confidence interval; DKQ, Diabetes Knowledge Questionnaire.

any significant associations. We also did not find any significant association between health literacy and medication adherence. Of note is that age was related to diabetes self-care (foot care), whereas race/ethnicity and health status were related to adherence. It is possible that among indigent populations, other unmeasured factors may be mediating these relationships such as patient-physician communication⁴⁸ and/or personal and social motivation.^{17,49} Additional studies are needed to better understand the mechanisms through which health literacy is related to diabetes self-care and medication adherence.

The major contribution of this study is that among low income, minority populations, diabetes knowledge and perceived health status are the most important factors associated with glycemic control. Limited health literacy appears to exert its influence through diabetes knowledge and is not directly related to diabetes self-care or medication adherence. Similar associations between health literacy and knowledge have been found in other studies. However, few studies on this population have included both self-care and adherence as covariates in their analysis. Interestingly, self-care and adherence were not related to literacy or glycemic control. One possible explanation is that these variables were measured by self-report, and future studies should utilize more objective measures when assessing these variables. This study needs to be replicated in other indigent and minority populations to assess consistency of the findings and identify potential explanatory factors. More importantly, it will be necessary to perform further assessments of multiple measures of health literacy in indigent and predominantly minority populations to better characterize the role of health literacy on self-care, glycemic control, and other aspects of diabetes outcomes.

This study has some limitations that are worth mentioning. First, this was a cross-sectional study, so we are not able to speak to causality or direction of the associations. Second, this study was conducted at a single academic center in the southeastern United States, and it is possible that our findings may not be representative of other indigent populations across the nation. However, the study highlights the need to be cautious in interpreting the effect of health literacy across diverse populations. Third, our measure of health literacy, the REALM-R, does not measure reading comprehension or numeracy, which are important components of health literacy. Finally, it is possible that the REALM-R is not a reliable measure of health literacy across diverse populations. However, in our population, the psychometric properties of the REALM-R showed that it was valid and reliable and consistent with the results from the initial validation studies of the scale.⁴² Fourth, despite adjusting for potential confounding variables in our analysis, we did not assess for other factors that may influence glycemic control such as duration of diabetes or diabetes complications. Populations with longer duration of disease or experience with complications may have worse glycemic control despite literacy level. Also, diabetes knowledge may be potentially influenced by duration of disease or complications. Although our findings that limited literacy related to poor disease knowledge is consistent with the literature, these variables should be included when evaluating health literacy, diabetes knowledge, and diabetes outcomes.

In conclusion, this study found that in a low income, predominantly minority population, diabetes knowledge and

perceived health status are the most important factors associated with glycemic control and that limited health literacy appears to exert its influence through diabetes knowledge and is not directly related to diabetes self-care or medication adherence. Our results lend support to tailoring educational interventions to the literacy needs of low income, predominantly minority patients. Such interventions by providers and educators are likely to be more effective at improving diabetes outcomes.

Author Disclosure Statement

No competing financial interests exist.

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