Health Literacy, Glycemic Control, and Physician-Advised Glucose Self-Monitoring Use in Type 2 Diabetes

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ABSTRACT

Objective. To measure the association between health literacy and both patient-reported and clinical outcomes in patients with non–insulin-treated type 2 diabetes.

Research Design and Methods. We surveyed patients with non–insulin-treated type 2 diabetes (n = 448) from 15 primary care practices. The association between health literacy and patient-reported and clinical outcomes, including numeracy of self-monitoring of blood glucose (SMBG) use, how often physicians advised patients to conduct SMBG testing, and glycemic control (as measured by A1C), was investigated.

Results. Study participants included 448 patients with non–insulin-treated type 2 diabetes located within central North Carolina. Participants with limited health literacy had poorer glycemic control (A1C 7.7 ± 1.1% vs. 7.5 ± 1.0%, P = 0.016) despite using SMBG testing more frequently (daily SMBG testing 49.3 vs. 30.7%, P = 0.001) compared to individuals with adequate health literacy. The difference in how often physicians advised patients to conduct SMBG testing between limited and adequate health literacy groups was not significant (P = 0.68).

Conclusion. Limited health literacy was associated with poorer glycemic control and an increased frequency of SMBG testing in patients with non–insulin-treated type 2 diabetes. There was no significant difference in how often physicians advised patients to conduct SMBG testing between patients with limited and adequate health literacy.

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Health literacy is not only the degree to which individuals can obtain and understand basic health information, but also includes their ability to act on that information to make informed health decisions (1). Lower levels of health literacy, and in particular reading ability, have been associated with a high prevalence of adverse health outcomes because of an inadequate use of health care services (2–6). In the context of type 2 diabetes, the impact of health literacy on health outcomes is not fully understood. The American Diabetes Association (ADA) continues to recommend that physicians prescribe self-monitoring of blood glucose (SMBG) to patients with noninsulin-treated type 2 diabetes, because SMBG is associated with meeting A1C targets (7,8). However, for SMBG to be useful, the ADA recommends integrating glucose values into clinical and self-management plans (8). Our study aimed to explore the association between patient health literacy and patient-reported outcomes such as numeracy of SMBG use, how often physicians advised patients to conduct SMBG testing, and the clinical outcome of glycemic

control as measured by A1C in patients with noninsulin-treated type 2 diabetes.

Research Design and Methods

Participants and Measures

This study used baseline data obtained from a parent study investigating whether SMBG testing in patients with noninsulin-treated type 2 diabetes and varying baseline characteristics led to improvements in patient-reported and clinical outcomes over time (9). In the parent study, there was no significant difference in glycemic control at 1 year between patients who performed once-daily SMBG and those who did not perform SMBG. Given the results, we examined the role of patient health literacy in overall glycemic control and SMBG usage (9). Our study population included 448 patients with noninsulin-treated type 2 diabetes who attended one of 15 University of North Carolina Health Care–associated primary care practices (family and internal medicine) located within central North Carolina. Eligible patients were ≥30 years of age and had an A1C level between 6.5 and 9.5% within 6 months preceding enrollment. Patients were excluded if they planned to see an endocrinologist within the next 12 months or if they planned to use insulin during the study period. The Newest Vital Sign (NVS) screening tool was used to assess health literacy in our patient population instead of other traditional tools for measuring health literacy. The NVS is easily administered in 3 minutes and is a research tool that uses a patient's ability to read and analyze a nutritional label to test prose literacy, numeracy, and document literacy (10). The NVS scores range from 0 to 6, with higher scores (≥4) associated with adequate health literacy (11). At baseline, all study participants were asked whether they currently use SMBG. If SMBG was used, participants indicated both how often they tested and how often they were told to test by their personal primary care physician. A1C levels were measured using venous blood draws and standard laboratory processing procedures.

Data Collection

Demographic, socioeconomic, and clinical characteristics were collected from baseline interviews with each patient.

Statistical Analysis

Data analysis was conducted on all 448 participants who had completed all baseline assessments. Wilcoxon rank sum and χ^2 tests were used to assess the mean difference in glycemic control, patient-reported frequency of SMBG testing, and how often physicians advised patients to conduct SMBG testing between patients with limited and adequate health literacy. NVS scores were dichotomized using the previously reported cutoff point of 4 to determine patient health literacy (≥4 indicates adequate health literacy) (7).

Results

Table 1 summarizes the demographic, socioeconomic, and clinical data obtained from each participant. Participants were relatively well-educated individuals, mostly married, and the majority female (54.0%), with an average age of 60.5 years. The mean A1C level of all respondents was 7.6% (±1.1%). A total of 38.2% of participants was determined to have limited health literacy. Participants with limited health literacy had significantly poorer glycemic control than participants with adequate health literacy (A1C 7.7 ± 1.1% vs. 7.5 ± 1.0%, $P = 0.016$).

Table 2 illustrates the frequency of SMBG testing completed by patients and how often patients were told to test by their physicians. The results are labeled as once daily, intermittently (not daily, but one or more times per week), and rarely (less than one time per week). Of the participants who were currently performing SMBG testing ($n = 336$), 55.7% had been told by their physicians to perform once-daily SMBG testing. There was no statistically significant difference in the frequency of which physicians told their patients to conduct SMBG testing between limited and adequate health literacy groups ($P = 0.68$) (Table 2). Of the participants who did not partake in SMBG testing ($n = 112$), 44.6% reported not doing so because they had not been advised by their physicians to test; and 16.1, 7.1, and 6.25% did not do so because of cost, pain associated with testing, and not understanding the benefits of testing, respectively.

Significantly more patients with limited health literacy performed once-daily SMBG testing significantly (once-daily SMBG testing 49.3 vs. 30.7%, $P = 0.001$) compared to individuals with adequate health literacy (Table 2).

Conclusion

Despite prior research indicating the unclear usefulness and cost-effectiveness of SMBG in patients with noninsulin-treated type 2 diabetes, this study illustrates that a majority (55.7%) of physicians who advise their patients to undergo SMBG testing advise them to test once daily. Despite most patients receiving the recommendation to conduct once-daily SMBG testing, 29.45% of patients who were not currently testing did not do so because of the cost of testing materials, the pain associated with testing, or their lack of understanding regarding the benefits of testing. This result aligns with research that indicates SMBG being useful and cost-effective only in patients who can incorporate their SMBG values in their diabetes care plan and treatment goals (12).

There was no significant difference in how often patients with noninsulin-treated type 2 diabetes and limited or adequate health literacy were told by their physicians to conduct SMBG testing. Regardless of each patient's health literacy status, the majority of physicians advised their patients to perform once-daily SMBG testing.

TABLE 1. Summary of Demographic and Clinical Data for All Participants With Limited Versus Adequate Health Literacy (*n* = 448)

Characteristic	Health Literacy	
	Limited* (*n* = 171)	Adequate (*n* = 277)
Age, years, mean (min, max)	64.3 (31, 92)	58.1 (32, 85)
Male, *n* (%)	86 (50.3)	121 (43.7)
Race, *n* (%)		
White	85 (49.7)	193 (69.7)
Black or African American	74 (43.3)	73 (26.4)
Other	12 (7.0)	11 (4.0)
Education, *n* (%)		
Less than high school	20 (11.7)	5 (1.8)
High school graduate/some college	127 (74.3)	142 (51.4)
College graduate or more	24 (14.0)	129 (46.7)
Marital status, *n* (%)		
Married/living together	106 (62.0)	189 (68.2)
Not married/living together	65 (38.0)	88 (31.8)
Number of comorbidities, mean (min, max)	3.7 (0, 10)	3.2 (0, 8)
Type 2 diabetes duration, years, mean (min, max)	9.2 (0, 44)	7.6 (0, 50)
BMI, kg/m^2, mean (min, max)	32.8 (21, 57)	35.2 (21, 75)
A1C, %, mean (min, max)	7.7 (6, 13)	7.5 (6, 13)
Current use of SMBG testing, *n* (%)		
Yes	134 (78.4)	202 (72.9)
No	37 (21.6)	75 (27.1)

**Limited health literacy defined as <4 on NVS assessment tool.*

TABLE 2. Comparison of Physician-Advised and Self-Reported SMBG Use in Patients With Limited Versus Adequate Health Literacy in Individuals Currently Using SMBG Testing (*n* = 336)

Outcome	Health Literacy		
	Limited (*n* = 134), *n* (%)	Adequate (*n* = 202), *n* (%)	*P*
Current frequency of SMBG testing			0.001
Once daily	66 (49.3)	62 (30.7)	
Intermittently	58 (43.2)	109 (54.0)	
Rarely	10 (7.5)	31 (15.3)	
How often told to SMBG test			0.682
Once daily	80 (59.7)	106 (53.0)	
Intermittently	24 (17.9)	43 (21.5)	
Rarely	2 (1.5)	3 (1.5)	
Not sure	28 (20.9)	48 (24.0)	

The need for individualized diabetes treatment plans has previously been called into question by research that determined that personal blood glucose testing patterns were frequently omitted by physicians and that many patients experience difficulty undertaking lifestyle changes (i.e., diet and exercise) based on the results of their regular SMBG testing (13). This study adds to the discussion regarding whether more individualized treatment plans can be used to aid patients in achieving better glycemic control and a higher quality of life.

There were several limitations to our study and data analysis. One-on-one patient interviews and

questionnaires were used to obtain patient-reported outcomes, including frequency of SMBG testing and how often physicians told their patients to conduct SMBG testing. Medical records were not used to determine the frequency of SMBG testing assigned by each patient's physician, which introduces the potential for recall bias. Furthermore, the reasons for increased frequency of SMBG testing in patients with limited health literacy were not examined in this study.

In the context of patient A1C levels, our study adds to previous research that has found a decreased level of glycemic control in patients with limited health literacy (14,15). Patients with limited health literacy have a decreased degree of glycemic control despite using SMBG testing significantly more often than individuals with adequate health literacy. This finding is paradoxical because numeracy of SMBG use is a measure of diabetes self-care, which is generally associated with better glycemic control. A decreased level of glycemic control despite using SMBG testing more often in patients with limited health literacy demonstrates the need for more rigorous patient education to ensure patients understand the true benefit of using SMBG testing and what can be done to manipulate their obtained blood glucose levels. In addition, avoiding unnecessary SMBG testing can reduce the pain and costs involved with routine SMBG testing, therefore minimizing the barriers involved with proper testing at times of necessity.

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Duality of Interest

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K.E.D. reports that her institution (UNC) has licensed to Telcare for the purposes of commercialization its interest in copyrighted work involving a glucose messaging and treatment algorithm.

No other potential conflicts of interest relevant to this article were reported.

Author Contributions

P.M.A. and K.E.D. wrote the manuscript and researched data. L.A.Y. reviewed/edited the manuscript. M.M., T.G.B., M.B.V., J.R., and K.G. contributed to discussion and data collection. J.B.B. reviewed/edited the manuscript. M.B.V. contributed to discussion and data collection. M.A.W. contributed to data analysis and reviewed/edited the manuscript. P.M.A. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Dewalt DA, Berkman ND, Sheridan S, Lohr KN, Pignone MP. Literacy and health outcomes: a systematic review of the literature. J Gen Intern Med 2004;19:1228–1239

2. Osborn CY, Cavanaugh K, Wallston KA, et al. Health literacy explains racial disparities in diabetes medication adherence. J Health Commun 2011;16:268–278

3. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. Ann Intern Med 2011;155:97–107

4. Jaffee EG, Arora VM, Matthiesen MI, Meltzer DO, Press VG. Health literacy and hospital length of stay: an inpatient cohort study. J Hosp Med 2017;12:969–973

5. Brigham EL, Goldenberg L, Stolfi A, Mueller G, Forbis SG. Associations between parental health literacy, use of asthma management plans, and child's asthma control. Clin Pediatr (Phila) 2016;55:111–117

6. Schillinger D, Grumbach K, Piette J, et al. Association of health literacy with diabetes outcomes. JAMA 2002;288:475–482

7. Elgart JF, Gonzalex L, Prestes M, Rucci E, Gagliardino JJ. Frequency of self-monitoring blood glucose and attainment of HbA1c target values. Acta Diabetol 2016;56:57–62

8. American Diabetes Association. Glycemic targets. Sec. 6. In *Standards of Medical Care in Diabetes—2018*. Diabetes Care 2018;41(Suppl. 1):S55–S64

9. Young LA, Buse JB, Weaver MA, et al. Glucose self-monitoring in non-insulin-treated patients with type 2 diabetes in primary care settings: a randomized trial. JAMA Intern Med 2017;177:920–929

10. Shealy KM, Threatt TB. Utilization of the Newest Vital Sign (NVS) in practice in the United States. Health Commun 2016;31:679–687

11. McCune RL, Lee H, Pohl JM. Assessing health literacy in safety net primary care practices. Appl Nurs Res 2016;29:188–194

12. Kutner M, Greenberg E, Jin Y, Paulsen C. *The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy (NCES 2006-483)*. Washington, DC: U.S. Department of Education, 2006

13. Nielsen-Bohlman L, Panzer AM, Kindig DA. *Committee on Health Literacy. Health Literacy: A Prescription to End Confusion*. Washington, DC: The National Academies Press, 2004

14. Souza JG, Apolinario D, Magaldi RM, Busse AL, Campora F, Jacob-Filho W. Functional health literacy and glycemic control in older adults with type 2 diabetes: a cross-sectional study. BMJ Open 2014;12:e004180

15. Chen GD, Huang CN, Yang YS, Lew-Ting CY. Patient perception of understanding health education and instructions has moderating effect on glycemic control. BMC Public Health 2014;14:683