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Authors

Quartuccio, Michael
Simonsick, Eleanor M
Langan, Susan
et al.

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The relationship of health literacy to diabetes status differs by sex in older adults

Michael Quartuccio^a, Eleanor M. Simonsick^b, Susan Langan^a, Tamara Harris^b, Rebecca L. Sudore^{c,d}, Roland Thorpe^e, Caterina Rosano^f, Felicia Hill-Briggs^{a,g,h}, Sherita Golden^{a,g,h}, Rita R. Kalyani^{a,h,*}

^a Division of Endocrinology, Diabetes & Metabolism, The Johns Hopkins University, Baltimore, MD, United States

^b Intramural Research Program National Institute on Aging, Baltimore, MD, United States

^c Division of Geriatrics, Department of Medicine, University of California, San Francisco, CA, United States

^d San Francisco Veterans Affairs Medical Center, San Francisco, CA, United States

^e Hopkins Center for Health Disparities Solution, The Johns Hopkins University, Baltimore, MD, United States

^f Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA, United States

^g Division of General Internal Medicine, Johns Hopkins University, Baltimore, MD, United States

^h The Welch Center for Prevention, Epidemiology and Clinical Research, The Johns Hopkins University, Baltimore, MD, United States

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ABSTRACT

Objective: Lower health literacy is associated with higher rates of mortality and chronic disease. It remains unclear whether health literacy is associated with diabetes and/or hyperglycemia in older adults, and if this relationship differs by sex.

Research design and methods: We performed a cross-sectional analysis of 2510 older adults in the Health, Aging and Body Composition (Health ABC) Study who had both a Rapid Estimate of Adult Literacy in Medicine (REALM) measurement and diabetes status available. Sex-stratified logistic regression models were used to analyze the relationship of health literacy categories (low, medium, and high) to diabetes status, adjusting for key covariates. Secondary analyses examined the relationship of health literacy to glycemic markers (A1C, fasting blood glucose).

Results: Among participants in the Health ABC cohort, 429 had diabetes. Mean age was 76 years old and 45% were female. Men with diabetes more commonly had low health literacy levels than men without diabetes (10.1% versus 9.3%, $p = 0.02$). Similar results were seen among women (14.7% versus 6.1%, $p < 0.01$). In a model adjusting for age, race, income, education, BMI, smoking, and alcohol use, women with low versus high health literacy had a two-fold higher likelihood of diabetes (OR = 2.2; 95% CI 1.1–4.3). No significant relationship was observed in men. Progressively lower categories of health literacy were associated with higher age-adjusted mean A1C and fasting blood glucose levels in women (both p for trend < 0.01) but not men.

Conclusions: In this large, ethnically diverse sample of community-dwelling older adults, lower health literacy level is related to a greater likelihood of diabetes and higher A1C and fasting blood glucose levels in women—but not in men—after adjusting for age, race, and other demographic and lifestyle factors. Future studies are needed to assess mechanisms underlying this relationship and if interventions to improve health literacy are effective in reducing the burden of diabetes, particularly in women.

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Health literacy has been defined as the level of ability to obtain, process, and understand basic health information in order to make health decisions.¹ While impacted by educational attainment, health literacy is distinct and specifically describes a person's understanding of health topics and the ability to navigate the health care system. Lower health

literacy has been associated with higher rates of chronic diseases,² higher rates of mortality,³ and higher risk of having undiagnosed diabetes.⁴ Furthermore, among those with diabetes, a small number of studies show that lower health literacy has been associated with higher A1C levels^{5,6} and higher rates of complications such as retinopathy⁵ and impaired foot ulcer healing.⁷ Limited health literacy is clearly a barrier to educating patients about diabetes.⁸ However, more research is needed in high-risk populations where both lower health literacy and diabetes may be more common, such as among older adults.⁹

There are no previous studies to our knowledge investigating sex differences in the relationship of literacy level to diabetes. While the assumption might be that the association is similar for both men and

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* Corresponding author at: Division of Endocrinology, Diabetes, & Metabolism, Department of Medicine, Johns Hopkins University School of Medicine, 1830 East Monument Street, Suite 333, Baltimore, MD 21287, United States.

E-mail address: rrastogi@jhmi.edu (R.R. Kalyani).

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women, this may not necessarily be the case. Health literacy levels appear to differ between sexes, with women generally observed to have higher health literacy in western cultures,^{10,11,12} though some studies show no difference.¹³ This relationship is less clear in other populations,^{14,15} and there is some evidence that men tend to over-report their health literacy,¹⁶ stressing the need for formal testing. Women tend to be more adherent to health care recommendations,¹⁷ but whether health literacy impacts that association is unclear. Assessing sex differences in the relationship between health literacy and diabetes is important to help identify potentially vulnerable sub-populations for targeted interventions.

Given the paucity of data on sex differences in the relationship of health literacy and diabetes, we aimed to investigate this relationship in a large, ethnically diverse population of older adults. We hypothesized that: 1) Lower health literacy levels would be associated with a higher likelihood of diabetes in a large, multi-ethnic, older population. 2) This relationship differs by sex. 3) Lower health literacy would be associated with relatively higher hemoglobin A1C and fasting blood glucose levels in both men and women, and among both those with and without diabetes.

1. Methods

1.1. Patient population

The Health, Aging and Body Composition (Health ABC) Study is a longitudinal cohort that began enrollment in 1997–98. The study population consisted of 3075 community-dwelling men and women, aged 70–79 years at baseline residing in Pittsburgh, PA or Memphis, TN. The group was diverse, with 45% of the women and 33% of the men identifying as African-American. The cohort members were selected at baseline to be free of reported difficulty walking 1/4 mile or difficulty climbing up 10 steps. In the current study, data from the Year 3 study visit, when health literacy was assessed, is examined. At year 3 of the study, 2543 attended the annual examination visit. Of this group, 3 persons were missing diabetes status and an additional 30 persons were missing health literacy assessment, leaving 2510 participants for the present analysis.

1.2. Health literacy assessment

The Rapid Estimate of Adult Literacy in Medicine (REALM) was developed as a quick screening tool to assist healthcare providers in estimating patient reading levels pertinent to medical communication. The REALM assessment has been well-validated to assess general health literacy.¹⁸ REALM was administered during an interview, where patients were asked to read a series of 66 health words, with one point given for each word pronounced correctly. A raw score of <45 (6th grade or less reading grade level) is considered low literacy, a score of 45–60 (7–8th grade reading grade level) is considered moderate literacy level, and a score of >61 (9th grade or higher reading) is considered adequate literacy level. Literacy levels are an indication of one's health literacy.^{19,20}

1.3. Diabetes assessment and covariates

While self-reported diabetes status was assessed yearly, diabetes status at the same visit as REALM test administration (year 3) was chosen as the primary outcome measure for appropriate cross-sectional analyses. Laboratory measures of hemoglobin A1c (HbA1c) and fasting plasma glucose (FPG) were used in secondary analyses, from year 4 which was the laboratory collection time point closest to REALM administration. Participant demographic information was collected at year 1 of the study and included age, sex, race, annual family income, and alcohol consumption status. For covariates that were collected at year 3 as

well, such as body mass index (BMI) and smoking status, this more recent information was used in analyses.

1.4. Statistical analysis

Differences in baseline characteristics between groups, dichotomized by diabetes status and stratified by sex, were calculated using the Student's *t*-test for continuous variables and Chi-squared tests for categorical variables. Logistic regression models were created to analyze health literacy as a predictor of diabetes status. The analysis was stratified by sex. For this analysis, because the ≤6th grade category was defined as the “low” health literacy category, the 7–8th grade level was defined as the “medium” health literacy category, and the ≥9th grade was defined as the “high” health literacy category. Data were analyzed in an unadjusted model, a model adjusted for demographic information of age, race, yearly income, and education (Model 1), and a model adjusted for demographics and health/lifestyle factors of BMI, smoking status, and alcohol status (Model 2). The primary outcome was self-reported diabetes status.

A secondary analysis studied the relationship of health literacy to levels of age-adjusted glycemic markers, both HbA1C and fasting plasma glucose. This secondary analysis was further stratified by sex and diabetes status. A sensitivity analysis stratified by race was also performed.

A two-tailed *p*-value of <0.05 was used to indicate statistical significance. All analyses were performed using SAS software (version 9.4 for Windows; SAS Institute, Cary, NC).

2. Results

Table 1 lists baseline characteristics of the cohort, by sex and diabetes status. Overall, average age were similar across groups, with a mean age of 76 years. In men, 41% of those with diabetes were African American, while 64% of women with diabetes were African American. In both sexes, those with diabetes had higher mean BMIs and lower education level, with women having a lower average level of education overall compared to men. Annual family income was lower in those with diabetes and further lower among women with and without diabetes. Smoking status did not differ by diabetes group, though women in each group were more likely to have been never smokers compared to men. Those with diabetes were less likely to drink alcohol in both sexes, with women having the lowest rates with or without diabetes. For women, mean REALM score was overall higher compared to men (mean REALM score 61.2 vs. 59.4; *p* ≤ 0.001) but, interestingly, women with diabetes had a lower mean REALM score compared to men with diabetes. As expected, both mean HbA1C and fasting glucose levels were higher in those with diabetes, without apparent sex differences.

Sensitivity analyses (data now shown) showed no significant interaction of race and health literacy category to the outcome of diabetes, so the results were pooled. When stratified by sex, among women (Table 2), those with low health literacy had a two-fold higher likelihood of having diabetes (Model 2; OR = 2.2; 95% CI 1.1–4.3) compared to those with high health literacy in the fully adjusted model. Women with medium health literacy were also more likely to have diabetes (Model 1; OR = 1.8; 95% CI 1.1–2.9) than those with high literacy, though the association was attenuated in the fully adjusted model (Model 2; OR = 1.6; 95% CI 1.0–2.6). Health literacy level was not related to diabetes in men (Model 2; OR = 0.7, 95% CI 0.4–1.2 comparing men in the low versus high health literacy category). In regression analyses, the interaction term for sex and health literacy category to the outcome of diabetes was significant in the unadjusted model (*p* < 0.01), Model 1 (*p* < 0.01), and Model 2 (*p* < 0.01).

In a secondary analysis of the association of health literacy categories and levels of glycemic markers, among women overall (Fig. 1A), a linear trend was observed with progressively higher health literacy categories

Table 1

Baseline characteristics by sex and diabetes status.

Characteristic	Men		Women		p-Values	
	Diabetes n = 238	No diabetes n = 965	Diabetes n = 191	No diabetes n = 1116	Within men	Within women
Age, mean (SD)	76.3 (2.6)	76.3 (2.9)	75.7 (2.7)	76.0 (2.8)	0.65	0.19
Race, (%)					0.004	<0.0001
White	59.2	69.1	36.1	60.7		
AA	40.8	30.9	63.9	39.3		
BMI (kg/m ²), mean (SD)	28.1 (3.8)	26.8 (3.9)	29.8 (5.4)	27.0 (5.3)	<0.0001	<0.0001
BMI (kg/m ²), (%)					0.0006	<0.0001
<25	23.1	32.5	19.9	39.2		
25–30	48.7	49.4	33.5	35.8		
>30	28.2	18.2	46.6	25.0		
Education level, (%)					0.02	0.0002
High School and below	27.3	20.6	31.4	17.7		
HS graduate/vocational/some college	47.5	45.1	55.0	60.1		
College graduate	11.3	17.8	5.8	11.2		
Graduate School	13.4	16.4	7.3	10.6		
Refused/missing	0.4	0.1	0.5	0.4		
Annual family income, (%)					0.04	<0.0001
<\$10,000	8.0	5.5	24.6	12.5		
\$10,000–\$25,000	34.9	29.2	37.2	35.0		
\$25,000–\$50,000	32.8	33.1	22.5	27.2		
>\$50,000	16.0	24.4	5.2	11.5		
Refused/don't know/missing	8.4	7.9	10.5	13.8		
Smoking behavior, (%)					0.10	0.89
Never smoked	18.9	23.6	61.3	59.4		
Ever smoked	73.9	66.7	30.4	31.7		
Current smoking	7.1	9.6	8.4	8.9		
Alcohol use in the past 12 months, (%)					0.0001	<0.0001
None	55.0	37.5	77.5	52.5		
Occasional	16.4	19.7	15.7	22.8		
1–7 drinks/week	21.4	29.3	6.3	20.4		
8–21 drinks/week	5.5	10.7	0.5	3.8		
22+ drinks/week	1.3	2.3	0	0.3		
Don't know/missing	0.4	0.5	0	0.2		
REALM score, mean (SD)	58.6 (11.1)	59.6 (12.3)	56.9 (15.2)	61.9 (9.3)	0.24	<0.0001
Health literacy grade level, (%)					0.02	<0.0001
9th grade or above	65.5	73.7	64.4	83.1		
7th–8th grade	24.4	17.0	20.9	10.8		
≤6th grade	10.1	9.3	14.7	6.1		
Mean hemoglobin A1C (%), mean (SD)	7.1 (1.4)	5.4 (0.6)	7.1 (1.4)	5.4 (0.6)	<0.0001	<0.0001
Mean fasting glucose (mg/dl), mean (SD)	136.4 (43.5)	97.4 (16.5)	142.4 (52.8)	92.7 (13.9)	<0.0001	<0.0001

being associated with relatively lower mean age-adjusted A1C levels (6.2%, 5.9%, and 5.6% across the low, medium, and high health literacy categories, respectively; p-value for trend < 0.001). Further, this significant trend remained across health literacy categories when women were stratified to those with (p = 0.04) and without (p = 0.02) diabetes. A similar relationship was found for fasting blood glucose among

women overall (Fig. 1C) (fasting blood glucose of 110, 108, and 98 mg/dl in the low, medium, and high health literacy categories, respectively; p-value for trend < 0.01).

For men overall, there was no significant relationship of higher health literacy categories to lower mean age-adjusted A1C (Fig. 1B, p-value for trend = 0.10) or fasting blood glucose (Fig. 1D, p-value for trend = 0.68).

Table 2

Odds ratios and 95% confidence intervals for the relationship of health literacy to diabetes, by sex.

	Unadjusted	Model 1 ^a	Model 2 ^b
Women			
High literacy ^c	Reference	Reference	Reference
Medium literacy ^d	2.5 (1.7–3.7)	1.8 (1.1–2.9)	1.6 (1.0–2.6)
	p-Value <0.0001	p-Value = 0.01	p-Value = 0.06
Low literacy ^e	3.1 (1.9–5.0)	2.0 (1.1–3.9)	2.2 (1.1–4.3)
	p-Value <0.0001	p-Value = 0.03	p-Value = 0.02
Men			
High literacy ^c	Reference	Reference	Reference
Medium literacy ^d	1.6 (1.1–2.3)	1.1 (0.8–1.7)	1.0 (0.7–1.6)
	p-Value = 0.006	p-Value = 0.54	p-Value = 0.84
Low literacy ^e	1.2 (0.8–2.0)	0.7 (0.4–1.3)	0.7 (0.4–1.2)
	p-Value = 0.42	p-Value = 0.31	p-Value = 0.20

p-Values for interaction, by model: Unadjusted (p = 0.0005); Model 1 (p = 0.0002); Model 2 (p = 0.0006).

^a Adjusted for Age, race, yearly income, education.

^b Adjusted for Age, race, yearly income, education, BMI, smoking status, alcohol status.

^c REALM ≥61.

^d REALM 45–60.

^e REALM ≤44.

3. Discussion

In a large, older, ethnically diverse cohort, women with lower health literacy were significantly more likely to have diabetes, independent of health-related and demographic variables including education level. A similar relationship was not observed in men. Further, women with relatively lower health literacy categories, both with and without diabetes, had higher mean A1C and fasting blood glucose levels suggesting that lower health literacy may further be related to the presence of hyperglycemia. The same relationship was not seen in men. Such differences by sex in the association of health literacy and diabetes, that we report in our study, may have potential implications for interventions used to prevent diabetes in women versus men.

Health literacy has been investigated as a source of health inequality and a barrier to health access.²¹ Those with limited health literacy are often more challenged to understand their providers' explanations of their disease state and plan of care and, thus, are less likely to engage in preventive care and follow prescribed directions. To date, few studies have examined sex differences in the association of health literacy and

Fig. 1. For all figures, “low” health literacy refers to a REALM score of <44, “medium” health literacy to a REALM score of 45–60, and “high” health literacy to a REALM score of ≥61. Fig. 1A: Age-adjusted mean HbA1c by REALM category in all women (n = 1173). Mean (SE) HbA1c values for women with a low health literacy (n = 76) were 6.2% (0.11), with medium health literacy (n = 143) were 5.9% (0.08), and high health literacy (n = 954) were 5.6 (0.03). The p-value for trend was <0.001. Fig. 1B: Age-adjusted mean HbA1c by REALM category in all men (n = 1081). Mean (SE) HbA1c values for men with a low health literacy (n = 96) were 5.9% (0.11), with medium health literacy (n = 197) were 6.0% (0.08), and high health literacy (n = 788) were 5.7% (0.04). The p-value for trend was 0.10. Fig. 1C: Age-adjusted mean fasting glucose by REALM category in all women (n = 1153). Mean (SE) fasting glucose values for women with a low health literacy (n = 78) were 110 mg/dl (3.25), with medium health literacy (n = 134) were 108 mg/dl (2.48), and high health literacy (n = 941) were 98 mg/dl (0.93). The p-value for trend was <0.01. Fig. 1D: Age-adjusted mean fasting glucose by REALM category in all men (n = 1064). Mean (SE) fasting glucose values for men with a low health literacy (n = 91) were 106 mg/dl (3.04), with medium health literacy (n = 193) were 105 mg/dl (2.09), and high health literacy (n = 780) were 105 mg/dl (1.04). The p-value for trend was 0.68.

disease states, and to our knowledge no previous studies have explored such sex differences in health literacy and diabetes.

In the Health ABC cohort, women had higher mean health literacy levels overall compared to men. This is consistent with other studies in the U.S. and elsewhere.^{10,11,12} In addition to higher health literacy, in one study involving participants from diverse races/ethnicities, women had greater familiarity with signs of diabetes when compared to men.²²

Mechanisms underlying the higher likelihood of diabetes in women, but not men, with lower health literacy are unclear. Women have been shown to utilize healthcare resources more than men,^{23,24,25,26,27} including in other chronic disease states such as asthma.²⁸ In the U.S., the greatest resource utilization disparity between sexes is seen in the age range of 45–65 years.²⁶ This middle-age category is arguably where healthcare interventions to prevent diabetes and its risk factors might be most effective. Additionally, women have higher levels of symptom-reporting,²⁴ which potentially could identify signs and symptoms of diabetes at an earlier stage. Thus, it may be expected that women with higher health literacy would be able to recognize risk

factors for diabetes and make interventions earlier to prevent this disease. Similarly, women with lower health literacy might be expected to be at higher risk for diabetes, but further investigation using longitudinal designs are needed.

Conversely, research shows that men tend to have low overall awareness of common health conditions, such as prostate cancer.²⁹ They also tend to wait longer to seek help after becoming ill.²³ However, interestingly, men may respond better to lifestyle interventions to delay or prevent diabetes. The U.S. Diabetes Prevention Program (DPP) was a large, multicenter trial of adults at elevated risk for developed type 2 diabetes, either because of overweight status or impaired fasting or impaired glucose state. Participants were randomized to either intensive lifestyle medication, metformin therapy, or placebo. A post-hoc analysis of the DPP lifestyle intervention data exploring sex differences showed that while the men had more risk factors for development of diabetes at baseline, they also had greater reductions in 2 h glucose and insulin resistance with weight loss of over 3% of body weight.³⁰ Though the etiology of the sex differences remains unclear, potential explanations as

to why we did not observe an association of health literacy to diabetes among men in our study may relate to these findings from other studies.

Strengths of our study include the use of a large, racially diverse cohort with robust measures of demographic, health, and laboratory data. The diversity allows for broader generalization of results. Adjustment for multiple potential confounders, including education level, allows for more confidence in the associations reported. Many studies of health literacy use a dichotomous outcome of “adequate health literacy”, often using the greater or less than 9th grade equivalent as the defining point. In contrast, our analysis investigated multiple levels of health literacy to further investigate relationships.

Limitations of our study include the cross-sectional study design which restricts inferences on temporality of relationships. We used odds ratios which may overestimate the magnitude of the effect, particularly for outcomes that are common. Future studies that investigate prevalence ratios may give further insights. Also, our results may not be generalizable to younger populations or other races/ethnicities, since the cohort did not include Spanish-speaking or Hispanic individuals. Since the outcome of diabetes was obtained via self-report, undiagnosed diabetes may have been missed, although this would have likely underestimated differences by health literacy categories. Yet, we also found a significant relationship between health literacy and laboratory measures of hyperglycemia (HbA1c and fasting glucose) in our study. REALM, though well-validated, is not diabetes-specific compared to other measures (i.e. the Diabetes Numeracy Test). However, REALM was the measure collected in Health ABC. While we did not find differences in race-stratified analyses, there may be differences in the relationship of health literacy to diabetes when stratified by both sex and race combined; unfortunately, we did not have the power to explore such differences in our study but this would be interesting to investigate in the future.

In this large, diverse sample of community-dwelling older adults, lower health literacy level is related to a greater likelihood of diabetes in women. Additionally, women with progressively lower health literacy levels had higher A1C values. This relationship was present among both women with and without diagnosed diabetes. Interestingly, similar relationships were not consistently present in men. Future studies are needed to assess potential mechanisms underlying these relationships and if interventions to improve health literacy are effective in reducing the burden of diabetes, particularly in women.

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