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Research Article

Do People with Lower Health Literacy Have Worse Diabetes Control? Insights from NHANES 2017–2020

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Abstract

Background: Glycemic control is necessary for reducing related complications in diabetic patients. However, disparities- often described as gaps in glycemic control- exist across all social and demographic groups. This study examines whether lower health literacy, proxied by educational attainment, is associated with low glycemic control among U.S. adults with diabetes.

Methods: Data were extracted from the 2017-2020 National Health and Nutrition Examination Survey (NHANES). 1,423 adults aged 18 and older who self-reported a diabetes diagnosis were included. Glycemic control was measured using hemoglobin A1c (HbA1c) levels. The level of education was used as a proxy for health literacy. Descriptive statistics and one-way ANOVA were conducted to compare mean HbA1c values across education groups, with post hoc Tukey tests used to measure pairwise differences.

Results: HbA1c levels is negatively associated with educational attainment. Participants with less a 9th-grade education had the highest mean HbA1c (7.78 %), while college graduates had the lowest (7.13%). ANOVA results showed a statistically significant difference between HbA1c across education levels $F(4,1253) = 3.59$, $p=0.006$). The only significant pairwise difference was between those with less than a 9th-grade education and college graduates ($p=0.003$).

Conclusion: Lower educational attainment, a proxy for limited health literacy, is associated with poorer glycemic control. These findings emphasize the need for diabetes education and management strategies designed for people with low literacy. This is needed to reduce disparities and improve health outcomes.

Kew Words: health literacy; diabetes; glycemic control; nhanes

Introduction

About 38.4 million persons, as of 2021, are diabetic in the United States [1]. This is 11.6% of the population, and out of this figure, 8.7 million persons are undiagnosed [2]. The reduction and progressive elimination of the incidence of diabetes is one of the goals of Healthy People 2030. But the 2017-2020 data from the Office of Disease Prevention and Health Promotion (ODPHP) of 18% suggests that no progress is being made towards bringing down the percentage of the U.S. adult population with HbA1c>9% from the 2016 baseline of 18.7% to the targeted 11.6% [3]. Importantly, individuals who are 18 and above are the most affected, constituting 99 percent of diabetic cases. Smalls et al. [4] posited that HbA1c, or Hemoglobin A1c, has a wide acceptance as an indicator of quality diabetes management, the possibility of developing diabetes-related complications, and a measure of severity of the condition. Therefore, there is a need to re-examine the existing data to identify and understand the factors affecting the *Healthy People 2030* goal of reducing the incidence of diabetes in the population. The purpose of this study is to determine whether people with lower health literacy have worse diabetes control. As such, it shall be argued that worse or adverse diabetes control is connected to significantly low health literacy and self-management.

Health literacy has been identified as critical to the improvement of self-management [5]. Health literacy is defined as a person's knowledge, capacity, and motive to gain, comprehend, and deploy health information for decision-making purposes across the health continuum [6]. As such, an individual's proficiency in critical health literacy is seen as a more effective method for increasing self-management behaviors, when contrasted with a sole reliance on self-confidence or social support mechanisms among people with chronic diseases. Conflating education with health literacy is not always straightforward, as a study of hospital emergency room visits found that

individuals with low health literacy and high education had a high probability of emergency room revisits [7]. At the same time, when health literacy is conceived as the use of reading, listening, data analysis, and decision-making skills during health situations, it was submitted that educational intervention is important for the enhancement of health literacy [8]. In other words, education is a sine qua non for health literacy, and by extension, self-management.

Health literacy has been associated with diabetes management, glycemic control, and self-efficacy of diabetes patients [9,10]. Health literacy influences diabetes knowledge, adherence to medication, and glucose monitoring [9]. Health literacy and self-management are central to the present study. There is limited recent U.S. national-level analysis using the National Health and Nutrition Survey data. Gaps in glycemic control are the disparities in blood glucose outcomes-importantly HbA1c levels, between subgroups of a given population. As such, these gaps or disparities often portray broader health inequities rooted in historical, social, economic, cultural, and educational disadvantages. Most studies on the gap/disparities in glycemic control have largely focused on race, ethnicity, and socio-economic factors as the predictors. As such, the studies largely focus on binary comparison of health outcomes and glycemic control between Blacks and Whites, or white versus Blacks and Latinos/Hispanics. For instance, studies that found low glycemic control by Blacks and Hispanics/Latinos often discount economic factors as explanatory variables [11-14].

Another category of studies, which largely discounted race, associated low glycemic control with factors like education level, Body Mass Index (BMI), duration of diabetes, aggregate cholesterol, clinical inertia due to attitudes of healthcare providers, therapy inertia due to cost and acceptability of insulin, access to Medicaid, and ineffectiveness of behavioral and technological interventions [15-18]. The above studies leave no room for individual self-efficacy based on personal beliefs and health knowledge. Consequently, there is a need to examine the likelihood of disparities in glycemic control between adults with high and low health literacy, as proxied by educational attainment.

Research Question

This study has a single research question: Do adults with lower educational attainment have higher HbA1c levels?

Objective

Examination of whether lower health literacy (measured via education) is associated with worse diabetes control (measured by HbA1c).

Theoretical Framework

The Health Belief Model (HBM) is one of the intrapersonal-level models of the behavioral foundations of public health [19]. The HBM focuses on the mode of the individual's perception of threats to health and the resultant decisive action, due to the premium

HBM Construct	Application to the Study
Perceived Susceptibility	Persons with low health literacy, proxied by education, may not fully understand their risk of diabetes complications
Perceived Severity	There is a possibility of underestimating the seriousness of, or the long-term damage caused by, high blood glucose.
Perceived Benefits	Limited health literacy could hamper the understanding of how lifestyle and medication influence health outcomes
Perceived Barriers	Barrier to action
Cues to Action	There is a possibility of ineffectiveness of health messages, doctors' advice, and appropriate reminders if not literacy-sensitive.
Self-Efficacy	Confidence is important to self-efficacy. Individuals with lower health literacy may feel less confident in managing their condition via appropriate health decisions.

Table 1

Each component of the HBM is influenced by health literacy. For instance, on self-efficacy, it has been noted that there is little or no incentive to act without the belief that individual action can produce desired results [21], and instructional practices often develop an individual's self-efficacy [22]. Importantly, health literacy has a direct effect on perceived susceptibility, perceived severity, and perceived barriers in the HBM [23]. Overall, HBM helps explain why individuals with lower literacy/education may have poorer self-care behaviors and outcomes in general and lower glycemic control in particular.

Methods

The study made use of the National Health and Nutrition Examination Survey 2017-2020, a cross-sectional and nationally representative study conducted by the Centers for Disease Control and Prevention (CDC). This makes it a secondary study with a quantitative research design. The sample inclusion and exclusion criteria are adults (age≥18) with self-reported diabetes (DIQ010=Yes).

Type of Variable	NHANES Code	Description
Health Literacy	DMDEDUC2	Education level (categorical)
Diabetes Control	LBXGH	HbA1c% (continuous)
Demographics	RIDAGEYR, RIAGENDR, RIDRETH3	Age, sex, race/ethnicity

Table 2: Key variables.

Analysis procedure

The study made use of descriptive (frequencies and means) and bivariate analysis (one-way ANOVA). The Tukey post hoc test was conducted for group differences. Analysis was done with the software, SPSS version 30.

Results

Sample Characteristics

The sample consisted of 1,423 U.S. adults with self-reported diabetes, drawn from 2017-2020 NHANES dataset. The gender distribution consists of

53.5% male and 46.5% female. Racial and ethnic composition is made up of 32.5% Non-Hispanic White, 28.8% Non-Hispanic Black, 12.8% Mexican American, 10.5% Other Hispanic, 10.2% Asian, and 5.2% of multiracial or other ethnicities. Education attainment is used here as the proxy for health literacy, and in terms of that, 13.1% of the study participants attained less than a 9th-grade education, 13.6% had no diploma (9 to 11th grade), 24.6% had graduated from high school or earned a GED, 30.9% had some university education or associate degree, and 17.8% graduated from college.

Education Level		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 9th grade	186	13.1	13.1	13.1
	9–11th grade (no diploma)	193	13.6	13.6	26.7
	High school/GED	349	24.5	24.6	51.3
	Some college/AA	438	30.8	30.9	82.2
	College graduate	252	17.7	17.8	100.0
	Total	1418	99.6	100.0	
Missing	System	5	.4		
Total		1423	100.0		

Table 3: Education Level.

Diagnosed with diabetes		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1423	100.0	100.0	100.0

Table 4: Diagnosed with diabetes.

Glycemic control by education level

The mean HbA1c values consistently declined with increasing education levels. Specifically, participants with less than 9th-grade schooling had the highest mean HbA1c (Mean=7.78%, Standard Deviation=1.77), while college/university graduates had the lowest mean HbA1c (Mean=7.13%, Standard Deviation=1.32). This pattern suggested a negative relationship between educational attainment and HbA1c levels.

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Glycohemoglobin (%) * Education Level	1258	88.4%	165	11.6%	1423	100.0%

Table 5: Aggregate glycohemoglobin by education values.

Glycohemoglobin (%)			
Education Level	Mean	Std. Deviation	N
Less than 9th grade	7.7753	1.76529	158
9–11th grade (no diploma)	7.5342	1.74066	158
High school/GED	7.5129	1.77263	317
Some college/AA	7.4640	1.76897	406
College graduate	7.1297	1.31595	219
Total	7.4661	1.70265	1258

Table 6: Mean Distribution.

The negative association between educational attainment and HbA1c levels is confirmed by a one-way ANOVA as statistically significant, F (4,1253) = 3.59, p=.006.

Glycohemoglobin (%)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.322	4	10.331	3.593	.006
Within Groups	3602.758	1253	2.875		
Total	3644.081	1257			

Table 7: One-way *ANOVA.*

Post hoc tests using the Tukey HSD test showed that the mean HbA1c for individuals with less than a 9th-grade was significantly higher than for participants with a university degree (p=.003). It is noteworthy that though other pairwise comparisons did not reach statistical significance, a visible trend associated lower HbA1c with higher levels of education. The homogenous subset analysis in Table 1.8 further supported this trend by grouping college graduates into a distinct subset with the lowest HbA1c values, while all other educational categories are grouped in the second, higher-risk clusters (higher HbA1c values).

Dependent Variable: Glycohemoglobin (%)						
Tukey HSD						
(I) Education Level	(J) Education Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Less than 9th grade	9–11th grade (no diploma)	.24114	.19078	.713	-.2800	.7623
	High school/GED	.26238	.16513	.505	-.1887	.7135
	Some college/AA	.31128	.15900	.288	-.1231	.7456
	College graduate	.64564*	.17700	.003	.1621	1.1291
9–11th grade (no diploma)	Less than 9th grade	-.24114	.19078	.713	-.7623	.2800
	High school/GED	.02124	.16513	1.000	-.4299	.4723
	Some college/AA	.07014	.15900	.992	-.3642	.5045
	College graduate	.40450	.17700	.150	-.0790	.8880
High school/GED	Less than 9th grade	-.26238	.16513	.505	-.7135	.1887
	9–11th grade (no diploma)	-.02124	.16513	1.000	-.4723	.4299
	Some college/AA	.04889	.12709	.995	-.2983	.3961
	College graduate	.38325	.14900	.076	-.0238	.7903
Some college/AA	Less than 9th grade	-.31128	.15900	.288	-.7456	.1231
	9–11th grade (no diploma)	-.07014	.15900	.992	-.5045	.3642
	High school/GED	-.04889	.12709	.995	-.3961	.2983
	College graduate	.33436	.14217	.130	-.0540	.7227
College graduate	Less than 9th grade	-.64564*	.17700	.003	-1.1291	-.1621
	9–11th grade (no diploma)	-.40450	.17700	.150	-.8880	.0790
	High school/GED	-.38325	.14900	.076	-.7903	.0238
	Some college/AA	-.33436	.14217	.130	-.7227	.0540
*. The mean difference is significant at the .050 level.						

Table 8: Multiple comparisons.

Glycohemoglobin (%)			
Tukey HSD[a,b]			
Education Level	N	Subset for alpha = .050	
		1	2
College graduate	219	7.1297	
Some college/AA	406	7.4640	7.4640
High school/GED	317	7.5129	7.5129
9–11th grade (no diploma)	158	7.5342	7.5342
Less than 9th grade	158		7.7753
Sig.		.092	.307
Means for groups in homogeneous subsets are displayed.			
a. Uses Harmonic Mean Sample Size = 218.894.			
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.			

Table 9: Homogenous subsets.

Discussion

In this study of 1,423 U.S. adults with self-reported diabetes (2017–2020 NHANES data), we identified a clear, graded inverse relationship between educational attainment—our proxy for health literacy—and glycemic control as measured by HbA1c. Specifically, those with less than 9th-grade education had the highest mean HbA1c (7.78 ± 1.77 %), whereas college graduates exhibited the lowest (7.13 ± 1.32 %). This gradient was statistically significant (ANOVA, F (4, 1253) = 3.59, p = .006), and post hoc pairwise comparisons revealed a significant difference between the lowest and highest education extremes (p = .003). Our results align well with previous observational and meta-analytic findings that lower educational levels or limited health literacy correlate with poorer glycemic outcomes. For example, meta-analytic evidence has consistently shown that lower health literacy is associated with reduced diabetes knowledge, self-care behaviors, and suboptimal glycemic control [24]. A more recent meta-analysis confirmed that interventions designed to improve health literacy can significantly reduce HbA1c levels [25].

Other observational investigations—such as those assessing literacy as a mediator between education and glycemic control—demonstrate similar patterns: patients with less formal education often struggle to understand diabetes management instructions, leading to persistently elevated HbA1c [26]. Thus, our pattern of highest HbA1c among the lowest-educated and lowest among the most educated is entirely consistent with the broader evidence base. The magnitude of difference we found, approximately 0.65 %

lower HbA1c in college graduates compared to those below 9th-grade, exceeds thresholds considered clinically relevant. The DCCT established that even 0.5 % reductions in HbA1c yield meaningful decreases in microvascular complications. Prior culturally tailored education programs achieved around 0.6–0.8 % reductions within months [27]. Hence, our observed difference aligns with effect sizes previously linked to improved long-term outcomes. Although we used educational attainment as a proxy, our findings strongly suggest that health literacy may mediate the observed relationship. Low educational achievement has been associated with limited health literacy, which in turn affects the ability to interpret medication instructions, adjust lifestyle, self-monitor blood glucose, and engage in preventive behaviors [28]. Interventional trials employing literacy-sensitive strategies, such as simplified language, teach-back methods, visuals, and culturally appropriate materials, have proven effective at improving both knowledge and glycemic outcomes [24]. Our sample's racial–ethnic makeup, 32.5 % non-Hispanic White, 28.8 % non-Hispanic Black, 12.8 % Mexican American, etc, mirrors known disparities in diabetes prevalence and outcomes. National data documents that adults with less than high school education have twice the diabetes prevalence of college graduates, and that Black and Hispanic populations bear a disproportionate burden of poor glycemic outcomes and complications [29]. Systemic barriers, including limited educational opportunity, food insecurity, and healthcare access gaps, compound low health literacy in these communities [30]. Given these findings, diabetes self-management education (DSME) programs should be explicitly designed for individuals with lower literacy levels. Strategies may include audio-visual aids, pictorial instruction, avoidance of medical jargon, simplified and actionable instructions, teach-back verification, and community health worker engagement. Meta-analyses show such tailored interventions can meaningfully reduce HbA1c [24,25]. Culturally competent interventions, those delivered by language-matched educators or community health workers, have previously led to ~0.8 % HbA1c reductions within three months [27].

Policy efforts should elevate health literacy as a core social determinant of health, integrate literacy assessment into clinical encounters, and support resource allocation for literacy-sensitive education materials in both clinical and community settings. Embedding these strategies into national initiatives, such as Healthy People 2030, would be consistent with calls to reduce health disparities via enhanced communication and access [31].

Limitations of the Study

As with other cross-sectional analyses, causality cannot be conclusively established; educational attainment likely correlates with numerous unmeasured social and economic factors such as income, access to care, and neighborhood environment. Additionally, education is an imperfect proxy for functional health literacy; direct measures of health literacy were not collected in NHANES during our period and may capture discrete cognitive, language, and numeracy skills more precisely (e.g. direct instruments, not education level). Nonetheless, the graded pattern observed across education categories, and its consistency with prior research that used validated literacy scales, supports our interpretation.

Conclusion

Gaps in Glycemic control refer to the disparities in blood glucose outcomes between population subgroups. These disparities often portray bigger health inequities that is grounded in socio-economic, educational, and historical disadvantages. This study has examined the probability of the existence of such disparity between adults with low literacy versus high health literacy. Educational attainment approximated health literacy, and it was found that there is negative association between educational attainment and HbA1c levels. In other words, the higher the educational attainment, the lower the HbA1C levels, and ipso facto, the higher the glycemic control. Stemming from above, a progressive improvement in health literacy is essential for closing diabetes control gaps between patients with higher and lower educational attainment. This is necessary for the attainment of the *Healthy People 2030* goal of the reduction of diabetes to 11 percent of the population.

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