



Association of Functional Health Literacy with Glycemic, Sleep, Lifestyle, and Sociodemographic Factors of Female Type 2 Diabetic patients in Bangladesh

Syed Billal Hossain^{1,2*}, Md Monirul Islam², Meheruba Khan Sinthia³, Kazi Mahfujur Rahman⁴,
Shahana Hoque², ABM Alauddin Chowdhury²

1- Department of Public Health, University of Science and Technology Chittagong, Chattogram, Bangladesh. (**Corresponding Author**) sbh.raaj@gmail.com

2- Department of Public Health, Daffodil International University (DIU), Dhaka, Bangladesh.

3- Department of Public Health and Informatics, Jahangirnagar University, Dhaka, Bangladesh.

4- Department of Statistics, Government Titumir College, Dhaka, Bangladesh.

Background and Objectives: The purpose of this study was to assess the association of Functional Health Literacy (FHL) level and glycemic control, sleep, lifestyle behaviors, and socio-demographic factors among female patients with diabetes in Bangladesh.

Material and Methods: It was a cross-sectional study among 337 patients with diabetes who visited 3 different diabetic centers in Dhaka city. A structured questionnaire including Bengali adaptation of the S-TOFHLA was used to collect data. Pearson's χ^2 test, and multi-nominal regression were used to find association of significant predictors with FHL level.

Result: Among participants, 22% had inadequate, 52% had marginal, and 26% had adequate FHL. FHL level was found significantly associated ($p < 0.05$) with sociodemographic (economic status, occupation, education), lifestyle (physical activity, job type, transportation, social media use), sleep duration/quality and clinical diabetes factors (treatment regimen, family history, FBS, HbA1c). Regression analysis revealed that Sleep duration and glycemic parameters significantly predicted functional health literacy (FHL). Compared to < 6 hours of sleep, durations of 6–8 hours (OR=10.38, 95% CI: 1.99–54.08, $p=0.01$) and > 10 hours (OR=7.24, 95% CI: 1.21–43.37, $p=0.03$) significantly increased the odds of inadequate FHL. Conversely, elevated glycemic markers paradoxically lowered inadequate FHL likelihood, including fasting blood sugar of 6.7–7.6 mmol/L (OR=0.003, $p=0.01$), postprandial glucose of 8.7–9.6 mmol/L (OR=0.000, $p < 0.001$), and HbA1c of 6.7–8.6% (OR=0.008, $p=0.05$). Furthermore, a sibling history of diabetes was significantly protective (OR=0.023, $p=0.05$). Education, occupation, income, physical activity, and treatment regimen show no significant independent effects in this model.

Conclusion: The findings highlight sleep duration and certain glycemic ranges as key correlates of functional health literacy, though the directionality of associations requires further investigation. Interventions to increase FHL may equivalently improve diabetes management. Future research should utilize longitudinal research designs to rigorously evaluate the efficacy of these health literacy interventions.

Keywords: Women, Health Literacy, Glycemic Control, Lifestyle, Sleep, Sociodemographic characteristics

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Introduction

Diabetes Mellitus (DM) is currently of the most prevalent non communicable diseases in the world. In many industrializing and developing countries, it is an epidemic. Approximately 589 million people worldwide currently have diabetes (1), with a prevalence of 10.5% in adults aged 20 to 79 (2) Bangladesh now has the eighth-highest number of diabetics worldwide, indicating that the disease is becoming more prevalent there. By 2045, Bangladesh is expected to rise to seventh place (1). According to studies, the prevalence of diabetes in women increased significantly from 11.25% in 2011 to 13.81% in 2018. Although there are some reports that indicate a slightly higher prevalence in men, the growth among women is significant (2).

The primary approach for reducing type 2 diabetes and its impact on patients and healthcare systems is diabetes management (3). Diabetes management entails extensive self-management techniques and right use of treatment regimens over time (4). Diabetic patients must follow a long-term self-management plan that includes stress management, blood glucose control, physical activity, medication management (including recommended dosages, frequency of administration, and optimal timing), foot care, and dietary self-control in order for their diabetes treatment plan to be successful (5). Functional Health Literacy is the ability to function effectively in healthcare settings as assessed by instruments that access the fundamental skills required to interact with written materials related to health (2). Adequate health literacy, in particular, enables persons with diabetes to understand prescription instructions, evaluate blood glucose measurements, follow dietary recommendations, and successfully navigate healthcare systems (6). In contrast, low health literacy is related to a number of adverse effects on care procedures and health outcomes, such as, difficulty naming drugs, misreading of treatment regimens, and decreased adherence to self-care measures (4). Health literacy is acknowledged as a stronger predictor of an individual's health than age, income, employment status, education level, or race (1). Patients with low health literacy are more likely to have inadequate knowledge of their disease and how to manage it, have trouble naming their medications and explaining indications and more often hold views on



health that make it difficult to follow their treatment regimens (7). Inadequate health literacy (HL) has been related independently to increased mortality rates, fewer preventative services used, more hospitalizations, worse general health, and less ability to take prescriptions as prescribed (8). People with chronic illnesses frequently have low HL levels and struggle with a variety of health-related information management issues (7).

Health literacy has a substantial impact on women's health and diabetes control, particularly in low-resource settings (9). While low health literacy is associated with more hospitalizations, medication errors, and poorer overall health, higher health literacy is directly associated with better overall health outcomes for women in general, including improved disease knowledge, increased physical activity, increased self-efficacy, and higher quality of life (4,9). Functional health literacy research is particularly important in Bangladesh where 67% of deaths are caused by Non-Communicable Diseases (NCDs) of all deaths across both genders and age groups (8). The burden is particularly heavy for Bangladeshi women with diabetes, as research shows that women in rural Bangladesh face significant barriers to diagnosis and treatment, and their health-related quality of life and glycemic control outcomes are directly impacted by lower education levels and socioeconomic limitations (10).

Even though various conceptual studies linking health literacy to diabetes self-care and clinical outcomes have been presented (4), the relationship of functional health literacy with glycemic level, lifestyle, sleep, and socio-demographic factors comprehensively, especially among Bangladeshi women was not found. Therefore, the current study is the first to assess level of FHL among Bangladeshi female patients with type-2 diabetes mellitus and determine their independent associations with glycemic status, lifestyle behaviors, sleep patterns, and sociodemographic characteristics, thereby providing evidence to inform gender-sensitive diabetes education and management strategies.

Materials and Methods

Study Design

It was a cross-sectional study among female patients with diabetes attending diabetes centers in Dhaka from July 2023 and January 2024. Samples were selected by a multistage approach by simple random sampling from two purposely selected diabetic centers situated in different areas of Dhaka city and one outside of the city area to ensure proportionate representation.

Sample Inclusion

The sampling strategy for this study was purposive, targeting a specific female patient, comprised patients with T2D over the age of 18 who live in Dhaka city and nearby district areas, visit Diabetic Centers for follow-up, have been on diabetic medications for at least 6 months, and have not been referred for inpatient or emergency care treatment. Purposive sampling was employed to deliberately select female diabetes patients, ensuring the cohort possessed specific clinical and social characteristics critical to investigating functional health literacy. This targeted approach optimizes data relevance and richness, facilitating a robust analysis of how literacy associates with glycemic control, lifestyle, sleep, and sociodemographic characteristics.

The sample size was determined using a single proportion formula for a population

$$n = \left(\frac{Z}{2}\right)^2 \frac{P(1-P)}{W^2}$$

n = preferred sample size, when the study population > 10,000

Z is the standard normal distribution set as 1.96, which corresponds to a 95% confidence interval.

$P=0.24$, Proportion in the target population estimated to have adequate health literacy (11)

$1-P=0.76$, proportion in the target population not having adequate health literacy

w = degree of accuracy required (set at 0.05 a marginal error)

Based on this

$$n = (1.96)^2 \times (0.24) \times (0.76) / 0.05^2 = 281.$$

Additionally, 20% non-respondent were considered ($n=56$), and total 337 female patients with Type 2 Diabetes were approached and included for survey from the study area. Specifically, this included 337 participants from Dhaka South City Corporation (DSCC) area ($n=125$), from Dhaka North City Corporation (DNCC) area ($n=112$), and from the Dhaka district area, adjacent to the Dhaka city corporation area ($n=100$).

The study incorporated an inclusive protocol for participation across diverse educational strata. Participants were categorized based on their educational attainment to determine the appropriate mode of survey administration. Individuals who had completed at least five years of formal education (the primary school level) were deemed to possess sufficient literacy for



self-administration. Participants were excluded if they hadn't given their consent, with mental health disorders, had a hearing issue, and/or had speech disability.

Questionnaire Development and Cross-Cultural Adaptation

A structured questionnaire was prepared which comprised of items focusing on sociodemographic characteristics, lifestyle, diabetic-related clinical information, and Short Test of functional health literacy (S-TOFHLA), a validated questionnaire based tool to assess the level of functional health literacy, treatment and glycemic level management (11–13). Sociodemographic factors such as age, sex, family structure, education, occupation, and household income provided contextual background. Diabetes-related variables included the duration of the condition, treatment regimens, other therapeutic supports, family and chronic disease history, as well as key glycemic indicators like Fasting Blood Sugar (FBS), 2-Hour After Breakfast Blood Glucose (2HABF) and Hemoglobin A1c (HbA1c). Lifestyle and physical activity variables assessed levels of exercise, job demands, transportation modes, sleep patterns, and media interactions. Dietary habits were explored through metrics like food quantity, dietary choices, alcohol intake, and smoking behavior.

The development of the survey instrument was guided by principles of cross-cultural adaptation to ensure linguistic equivalence and conceptual relevance for the target population. The primary instrument, comprising a demographic questionnaire and the Short Test of Functional Health Literacy in Adults (S-TOFHLA), underwent a systematic translation from English to Bengali. This process was augmented by a review from a panel of public health experts who recommended the contextualization of healthcare terminology. Specifically, US-centric terms such as "County" and "Medicaid" were replaced with their functional Bangladeshi equivalents, "District" and "Shasthyo Surokhsha Karmasuchi (SSK)," respectively, to enhance respondent comprehension and ecological validity.

Questionnaire Administration including S-TOFHLA

The prepared questionnaire including S-TOFHLA was tested by a pilot survey among 15 (5% of estimated sample size) non-participant samples to assess the feasibility and validity of the questionnaire. After the piloting some minor corrections were made in translation and mode of language of the Questionnaire. The mode of administration was designed to be responsive to the varying literacy levels within the population. The instrument was formatted for self-administration among literate participants. Participants who were unable to read or write in



either Bengali or English were classified as non-literate. For this subgroup, the survey was exclusively administered through the verbally assisted method by trained, native-speaking data collectors. Native Bengali-speaking data collectors read the questions aloud in a manner analogous to a structured interview, ensuring that the integrity of the item stems and response options was maintained while facilitating participation. This approach mitigated measurement bias that would otherwise arise from the exclusion of non-literate individuals, thereby strengthening the external validity of the study findings by representing a broader spectrum of the patient population. As the instrument was presented in their native tongue (Bengali), the majority of these participants completed the survey independently. However, to ensure data quality and accurate comprehension, verbal guidance was available and provided upon request to clarify any complex questions.

Measures and operational definitions

Functional health literacy was assessed using the validated Short Test of Functional Health Literacy in Adults (S-TOFHLA), which categorizes patients as inadequate (<17), marginal (17-22), or adequate (23-36) level of FHL based on the score (11–13).

FBS and HbA1c data within the past one month from medical records were used to evaluate glycemic management. Patients were classified into three groups based on their HbA1c levels: adequate control (7%), fair control (7.1-8%), and inadequate control (>8%) of diabetes.

According to the level of physical functioning and activity, participants were categorized as, No activity: Activity that involves sitting or lying down, with little energy expenditure; Light activity: Day to day home, workplace or community based activity; and Moderate to vigorous activity: Activities that cause a noticeable increase in heart and breathing rates (14).

Data analysis method

The information from the interviews was verified repeatedly before it was entered into computer. Incomplete data were discarded. The data collected for this study was processed and analyzed using IBM SPSS Statistics version 26. Initially, descriptive statistics were used to summarize the participants' clinical and sociodemographic profiles, calculating frequencies and percentages for each variable. Bivariate analysis was used using Pearson's chi-square tests to investigate into potential correlations between explanation variables and Functional Health Literacy (FHL) levels. When significant associations emerged, the Cramér's V coefficient was used to assess the association's strength. In order to determine the



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independent predictors of FHL categories while taking confounders into consideration, a multinomial logistic regression analysis was also performed out. The model's fit was assessed using chi-square tests, -2 Log Likelihood, and pseudo-R² metrics (Cox & Snell, Nagelkerke, and McFadden). For all analyses, a p-value of less than 0.05 was considered statistically significant. Every method closely adhered to a structured analysis strategy that was prepared in advance in order to maintain consistency and coherence across the data interpretation stages.

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Results

Descriptive analysis

Table 1 summarizes the socio-demographic, lifestyle, and clinical characteristics of 337 respondents. The mean age was 51.4 years (SD=4.2), with the highest proportion (32.6%) in the 40–59 age bracket. Educational attainment was distributed across levels, below secondary (40.9%) and secondary schooling being most common (23.7%). A majority were homemakers (57.6%), and mean monthly income was 27,504 BDT (SD=11,232); notably, 62.6% earn below 10,000 BDT (approximately 82 US dollars). Urban residency (62.9%) and married status (90.5%) were predominated.

Diabetes duration averages 5.3 years (SD=8.7) while, oral medication alone was the predominant treatment (68.8%). Family history of diabetes was most frequent among parents (48.1%). Mean current fasting blood glucose was 7.9 mmol/L (SD=6.3), three-month mean fasting glucose 7.2 mmol/L (SD=5.7), three-month mean postprandial glucose (2HABF) 9.8 mmol/L (SD=5.3), and mean HbA1c 8.2% (SD=5.8).

Smokeless tobacco consumption is reported by 43.9%. Light daily physical activity (30 min) was observed in 64.4%, and light-activity transport in 73.8%. Most respondents engage in moderate occupational activity (64.7%). Self-perception on sleep quality was rated good by 84.0%, with mean sleep duration 6.6 hours (SD=3.1). Average television and social media use were 1.9 hours (SD=3.8) and 2.1 hours (SD=2.7), respectively.

Collectively, the data of the study represent a middle-aged, predominantly low-income urban cohort with suboptimal glycemc control and notable tobacco use.

Table 1. Socio-demographic, lifestyle and clinical characteristics of respondents

Variables	Categories	N (337)	(%)
Age Mean ± SD = 51.4 ± 4.2	30 to 39	60	17.8
	40 to 59	203	59.6
	above 59	74	22.0
Education	Below Secondary school	138	40.9
	Secondary School	80	23.7
	Higher Secondary School	62	18.4
	Bachelor or above level	57	16.9
Occupation	Homemaker	194	57.6
	Unemployed/Student	28	8.3
	Employed/Business	115	34.1
	Total	337	100.0
Income in BDT	less than 10000	211	62.6



Mean \pm SD = 17504 \pm 11232	10001 to 29000	51	3.3
	More than 29000	75	8.6
Living Area	Urban/City	212	62.9
	Rural/Village	125	37.1
Marital Status	Single	1	0.3
	Married	305	90.5
	Widowed/Divorced	31	9.2
Consume any form of smokeless tobacco	Yes	148	43.9
	No	189	56.1
Physical Activity every day for 30 min.	No	120	35.6
	Light Physical Activity	217	64.4
Transport Means	Sedentary transport	36	10.7
	Light Activity Transport	249	73.8
	Moderate to Vigorous	52	15.5
Job nature	No Activity (sedentary)	51	15.1
	Light Activity	44	13.1
	Moderate Activity	218	64.7
	Vigorous Activity	24	7.1
Self-perception on Sleep Quality	Not good	54	16.0
	Good	283	84.0
Sleep Hours per day Mean \pm SD = 6.6 \pm 3.1	less than 6 hours	21	6.2
	6 to 8 hours	314	93.2
	more than 10 hours	2	0.6
TV Hour per day Mean \pm SD = 1.9 \pm 3.8	less than 2 hours	316	93.8
	2 to 4 hours	21	6.2
Duration in social media per day Mean \pm SD = 2.1 \pm 2.7	Never	150	44.5
	less than 2 hours	178	52.8
	2 to 4 hours	9	2.7
DM duration Mean \pm SD = 5.3 \pm 8.7	Up to 3 years	112	33.3
	4 to 6 years	119	35.3
	more than 6 years	106	31.5
Treatment regimen	Oral Medicine	232	68.8
	Insulin Dose	6	1.8
	Both Oral & Insulin	99	29.4
DM family history	None	55	16.3
	Parents	162	48.1
	Siblings	99	29.4
	Grandparents	1	0.3
	Second degree relatives	20	5.0
Current Fasting Blood Sugar (FBS) Mean \pm SD = 7.9 \pm 6.3	less than 5.7	8	2.4
	5.7 to 8.6	147	43.6
	more than 8.6	182	54.0
3 months' mean FBS Mean \pm SD = 7.2 \pm 5.7	less than 5.7	4	1.2
	5.7 to 8.6	217	64.4
	more than 8.6	116	34.4
3 months' mean 2HABS (2-Hour Postprandial Blood Glucose) Mean \pm SD = 9.8 \pm 5.3	less than 7.7	9	2.7
	7.7 to 10.6	188	55.8
	more than 10.6	140	41.5



Hemoglobin A1c (HbA1c) Mean ± SD = 8.2 ± 5.8	Up to 6.6	48	14.2
	6.7 to 9.6	200	59.3
	more than 9.6	89	26.4

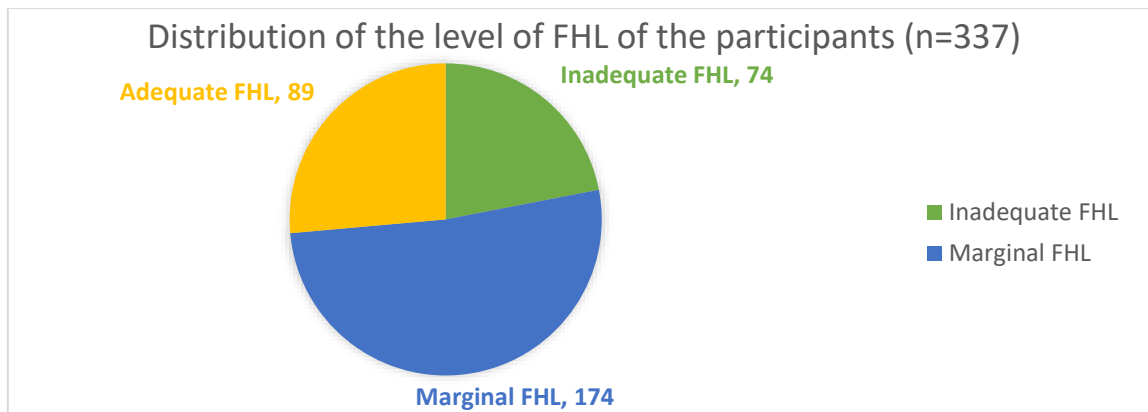


Figure 1. Distribution of the participants according to categories of FHL Level

The distribution of participants across these FHL categories is visually presented in Figure 1, it was found that 22% (n=74) respondents had inadequate FHL, 52% (n=174) had marginal, and 26% (n=89) had adequate FHL (Figure 1).

Bivariate Analysis

Bivariate relationships were analyzed utilizing Pearson's chi-square tests, with the strength of associations determined by Cramer's V coefficient. The distribution of functional health literacy (FHL) levels across sociodemographic factors, physical activity characteristics, and glycemic control indicators is presented in Table 2 through 4.

Table 2 presents bivariate associations between sociodemographic factors and functional health literacy (FHL) levels. Education shows the strongest significant association ($\chi^2=53.669$, $p<0.001$, Cramer's $V=0.282$), indicating a moderate effect size. Notably, no respondent with a master's or higher education had inadequate FHL, whereas 64.7% attained adequate levels. Income also demonstrates a significant relationship ($p=0.001$, $V=0.227$); all participants earning $\geq 60,000$ BDT achieved adequate FHL. Occupation was significant ($p=0.005$, $V=0.148$), with employed/business individuals showing higher adequate FHL (33.0%) compared to homemakers (22.2%). Conversely, age ($p=0.966$), living area ($p=0.442$), and marital status ($p=0.755$) were not significantly associated with FHL. The Cramer's V values for education and income suggest practically meaningful associations, whereas occupation's strength is modest.



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These findings highlight socioeconomic position, particularly education and income, as key determinants of adequate health literacy in this cohort.

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Table 2. Bi-variate association of Sociodemographic Characteristics with Level of FHL

Variables		FHL Level			Chi-Square	p-value	Cramer's V
		Inadequate (n=74)	Marginal (n=174)	Adequate (n=89)			
Age	30 to 39	14 (23.33%)	30 (50%)	16 (26.66%)	2.399	0.966	0.060
	40 to 59	43 (21.18%)	106 (52.22%)	54 (27.60%)			
	above 59	17 (23.0%)	38 (51.35%)	19 (26.65%)			
Education	Below Secondary school	55 (37.16%)	76 (51.35%)	17 (11.49%)	53.669	0.000	0.282
	Secondary School	19 (23.8%)	39 (48.8%)	22 (27.5%)			
	Higher Secondary School	8 (12.9%)	34 (54.8%)	20 (32.3%)			
	Bachelor or above level	2 (3.51%)	25 (43.86%)	30 (52.63%)			
Occupation	Homemaker	55 (28.4%)	96 (49.5%)	43 (22.2%)	14.824	0.005	0.148
	Unemployed/Student	7 (25.0%)	13 (46.4%)	8 (28.6%)			
	Employed/Business	12 (10.4%)	65 (56.5%)	38 (33.0%)			
Income	less than 10000	60 (28.4%)	103 (48.8%)	48 (22.7%)	34.688	0.001	0.227
	10001 to 29000	4 (7.85%)	33 (64.70%)	14 (27.45%)			
	More than 29000	10 (13.33%)	38 (50.67%)	27 (36.0%)			
Living Area	Urban/City	48 (22.6%)	104 (49.1%)	60 (28.3%)	1.631	0.442	0.070
	Rural/Village	26 (20.8%)	70 (56.0%)	29 (23.2%)			
Marital Status	Single	0 (0.0%)	1 (100.0%)	0 (0.0%)	1.894	0.755	0.053
	Married	66 (21.6%)	156 (51.1%)	83 (27.2%)			
	Widowed/Divorced	8 (25.8%)	17 (54.8%)	6 (19.4%)			

Table 3 presents bivariate associations between diabetes-related variables and functional health literacy (FHL). Hemoglobin A1c shows the strongest significant association ($\chi^2=100.410$, $p<0.001$, Cramer's $V=0.386$), a moderate-to-strong effect size. Among participants with HbA1c $>10.6\%$, 56.4% had inadequate FHL compared to only 3.6% with adequate levels. Current fasting blood sugar ($V=0.364$), three-month mean fasting blood sugar ($V=0.355$), and postprandial glucose (2HABF) ($V=0.355$) also demonstrate strong significant associations ($p<0.001$). Family history of diabetes is significant ($p<0.001$, $V=0.218$); notably, all respondents with affected grandparents achieved adequate FHL. Treatment regimen shows a modest but significant association ($p=0.008$, $V=0.160$). Conversely, diabetes duration is not significantly associated ($p=0.594$). These findings indicate that poorer glycemic control is consistently and strongly linked to lower health literacy levels.



Table 3- Bi-variate association of Diabetes and treatment related variables with Level of FHL

Variables		FHL Level			Chi-Square	p-value	Cramer's V
		Inadequate (n=74)	Marginal (n=174)	Adequate (n=89)			
DM duration	Up to 3 years	22 (19.64%)	61 (54.46%)	29 (25.89%)	6.476	0.594	0.098
	4 to 6 years	26 (21.8%)	61 (51.3%)	32 (26.9%)			
	more than 6 years	28 (26.42%)	52 (48.06%)	28 (26.42%)			
Treatment Regimen	Oral Medicine	41 (17.8%)	119 (51.7%)	72 (30.4%)	17.243	0.008	0.160
	Insulin Dose	2 (33.3%)	3 (50.0%)	1 (16.7%)			
	Both Oral & Insulin	31 (31.3%)	52 (52.5%)	16 (16.2%)			
DM family history	None	11 (20.0%)	42 (76.4%)	2 (3.6%)	32.101	0.000	0.218
	Parents	31 (19.1%)	79 (48.8%)	52 (32.1%)			
	Siblings	25 (25.3%)	45 (45.5%)	29 (29.3%)			
	Grandparents	0 (0.0%)	0 (0.0%)	2 (100.0%)			
	Second degree relatives	7 (35.0%)	8 (40.0%)	5 (25.0%)			
Current FBS (Fasting Blood Sugar)	less than 5.7	1 (12.5%)	5 (62.5%)	2 (25.0%)	89.337	0.000	0.364
	5.7 to 8.6	16 (10.88%)	73 (49.66%)	48 (32.65%)			
	more than 8.6	57 (31.32%)	96 (52.75%)	29 (15.93%)			
3 months' mean FBS	less than 5.7	0 (0.0%)	2 (50.0%)	2 (50.0%)	84.781	0.000	0.355
	5.7 to 8.6	22 (10.14%)	120 (55.30%)	75 (34.56%)			
	more than 8.6	52 (44.83%)	52 (44.83%)	12 (10.34%)			
3 months' mean 2HABS (2-Hour Postprandial Blood Glucose)	less than 7.7	0 (0.0%)	4 (44.4%)	5 (55.6%)	85.105	0.000	0.355
	7.7 to 10.6	19 (10.11%)	98 (52.13%)	71 (38.83%)			
	more than 10.6	55 (39.29%)	72 (51.43%)	13 (9.29%)			
Hemoglobin A1c (HbA1c)	Up to 6.6	2 (0.0%)	18 (100.0%)	28 (0.0%)	100.410	0.000	0.386
	6.7 to 9.6	25 (12.50%)	119 (59.50%)	56 (28.00%)			
	more than 9.6	47 (52.80%)	37 (41.57%)	5 (5.61%)			



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Table 4 examines bivariate associations between lifestyle and sleep variables with functional health literacy (FHL). Physical activity demonstrates the strongest significant association ($\chi^2=29.240$, $p<0.001$, Cramer's $V=0.295$), a moderate-to-strong effect size. Among respondents reporting no daily physical activity, 38.3% had inadequate FHL compared to only 12.9% with light activity. Sleep duration ($p<0.001$, $V=0.180$) and social media use ($p<0.001$, $V=0.183$) were also significantly associated. Notably, all individuals sleeping over 10 hours achieved adequate FHL, and those using social media less than two hours daily had higher adequate FHL (34.8%) than never-users (15.3%). Self-perception on sleep quality ($p=0.002$, $V=0.191$), job nature ($p=0.002$, $V=0.189$), and transport means ($p=0.001$, $V=0.186$) show modest but significant associations. Conversely, alcohol habit, smokeless tobacco use, and TV hours were not significantly related to FHL. These findings underscore a notable pattern emerged wherein participants with adequate FHL were more frequently associated with positive health behaviors, including good sleep quality, optimal sleep duration (6–8 hours), and higher physical activity. Lower FHL was significantly associated with both shorter sleep duration and poor sleep quality. Conversely, sedentary occupations and physical inactivity were more prevalent among those with poorer FHL.



Table 4- Bi-variate association of Lifestyle and sleep related variables with Level of FHL

Variables		FHL Level			Chi-Square	p-value	Cramer's V
		Inadequate (n=74)	Marginal (n=174)	Adequate (n=89)			
Consume smokeless tobacco	Yes	33 (22.3%)	79 (53.4%)	36 (24.3%)	0.604	0.739	0.042
	No	41 (21.7%)	95 (50.3%)	53 (28.0%)			
Physical Activity every day for 30 min.	No	46 (38.3%)	50 (41.7%)	24 (20.0%)	29.240	0.000	0.295
	Light	28 (12.9%)	124 (57.1%)	65 (30.0%)			
Transport Means	Sedentary transport	4 (11.1%)	14 (38.9%)	18 (50.0%)	23.315	0.001	0.186
	Light Activity Transport	54 (21.1%)	130 (52.6%)	65 (26.3%)			
	Moderate to Vigorous	16 (30.8%)	30 (57.7%)	6 (11.5%)			
Job nature	Sedentary	3 (5.9%)	24 (47.1%)	24 (47.1%)	23.949	0.002	0.189
	Light Activity	9 (20.5%)	20 (45.5%)	15 (34.1%)			
	Moderate Activity	56 (25.9%)	114 (51.9%)	48 (22.2%)			
	Vigorous Activity	6 (25.0%)	16 (66.7%)	2 (8.3%)			
Self-perception on Sleep Quality	Not good	20 (37.0%)	28 (51.9%)	6 (11.1%)	12.357	0.002	0.191
	Good	54 (19.1%)	146 (51.6%)	83 (29.3%)			
Sleep Hours every day	less than 6 hours	12 (57.1%)	7 (33.3%)	2 (9.5%)	21.940	0.000	0.180
	6 to 8 hours	62 (19.7%)	167 (53.2%)	85 (27.1%)			
	more than 10 hours	0 (0.0%)	0 (0.0%)	2 (100.0%)			
TV Hour everyday	less than 2 hours	72 (22.8%)	160 (50.6%)	84 (26.6%)	2.615	0.271	0.088
	2 to 4 hours	2 (9.5%)	14 (66.7%)	5 (23.8%)			
Duration in social media everyday	Never	46 (30.7%)	81 (54.0%)	23 (15.3%)	22.602	0.000	0.183
	less than 2 hours	27 (15.2%)	89 (50.0%)	62 (34.8%)			
	2 to 4 hours	1 (11.1%)	4 (44.4%)	4 (44.4%)			

Multivariate Analysis

Variables demonstrating a significant association with overall Functional Health Literacy (FHL) level in the bivariate analysis ($p < 0.05$) were entered into a multinomial logistic regression model to ascertain independent predictors (Table 5 and 6). The final model demonstrated a good fit to the data (Table 5), as indicated by a significant omnibus test (-2 Log Likelihood = 349.221, $\chi^2 = 342.184$, $df = 114$, $p < 0.001$). The substantial proportion of variance explained by the model was further supported by pseudo-R-squared values (Cox & Snell $R^2 = 0.638$, Nagelkerke $R^2 = 0.732$, McFadden $R^2 = 0.495$). Table 6 presents a multinomial logistic regression comparing factors associated with inadequate versus adequate functional health literacy (FHL). Among sleep-related variables, sleep duration emerged as a significant predictor. Relative to sleeping less than 6 hours, sleeping 6–8 hours significantly increase the odds of inadequate FHL (OR=10.38, 95% CI: 1.99–54.08, $p = 0.01$), as does sleeping more than 10 hours (OR=7.24, 95% CI: 1.21–43.37, $p = 0.03$). These striking associations suggest that both moderately short and extended sleep are linked to poorer health literacy, though the wide confidence intervals warrant cautious interpretation.

Table 5- Summary of the multinomial logistic regression model

Model Summary ^a							
Step	Chi Sq.	df.	Sig.	-2 Log likelihood	Cox & Snell R ²	Nagelkerke R ²	McFadden R ²
1	342.184	114	0.000	349.221 ^a	0.638	0.732	0.495

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Table 6- NMultinomial Logistic Regression of Factors Associated with Functional Health Literacy Level (Inadequate vs Adequate)

Variable	B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
[Education= Below Secondary]	0.11	0.854	0.017	1	0.9	1.119	0.218	5.743
[Education=Secondary]	0.06	0.812	0.006	1	0.94	1.066	0.227	5.006
[Education=Higher secondary]	0.07	0.819	0.007	1	0.93	1.073	0.229	5.148
[Education=Bachelor or above]	0.06	0.8	0.005	1	0.95	1.06	0.231	4.865
[Occupation= Homemaker]	3.51	2.084	2.839	1	0.09	33.522	0.564	1993.667
[Occupation=Unemployed/Student]	1.93	2.03	0.9	1	0.34	6.864	0.128	366.979
[Income=10000 to 29000]	0.34	0.845	0.163	1	0.69	1.406	0.278	7.11
[Income=More than 29000]	0.32	0.82	0.151	1	0.7	1.374	0.28	6.739
[Physical Activity= No]	0.7	0.678	1.054	1	0.31	2.005	0.531	7.573
[Transport Means= Sedentary transport]	-0.42	0.842	0.249	1	0.62	0.657	0.129	3.349
[Transport Means= Light Activity Transport]	-0.31	0.836	0.133	1	0.72	0.737	0.149	3.645
[Transport Means= Moderate to Vigorous]	-0.52	0.854	0.368	1	0.54	0.596	0.112	3.165
[Job nature= Sedentary]	-0.79	0.902	0.767	1	0.38	0.454	0.08	2.571



[Job nature= Light Activity]	-0.67	0.876	0.581	1	0.45	0.513	0.096	2.747
[Job nature= Moderate Activity]	-0.65	0.88	0.548	1	0.46	0.521	0.097	2.811
[Job nature= Vigorous Activity]	-0.51	0.862	0.352	1	0.55	0.6	0.118	3.071
[Sleep Quality= Good]	1.26	0.963	1.71	1	0.19	3.525	0.534	23.288
[Sleep Hours=6 to 8 hours]	2.34	0.865	7.319	1	0.01	10.384	1.994	54.081
[Sleep Hours= more than 10 hours]	1.98	0.911	4.716	1	0.03	7.242	1.21	43.368
[Social media use = less than 2 hours]	0.92	0.952	0.927	1	0.34	2.5	0.39	15.999
[Social media use=2 to 4 hours]	0.95	0.94	1.024	1	0.31	2.589	0.418	16.02
[Treatment regimen= Oral Medicine]	0.65	0.821	0.636	1	0.43	1.924	0.389	9.514
[Treatment regimen= Insulin Dose]	-0.4	0.788	0.26	1	0.61	0.669	0.143	3.135
[Treatment regimen= Both Oral & Insulin]	0.89	0.86	1.078	1	0.3	2.44	0.451	13.22
DM family history= Parents	-1.26	2.105	0.36	1	0.55	0.283	0.005	17.502
DM family history= Siblings	-3.78	1.921	3.879	1	0.05	0.023	0.001	0.982
DM family history= Grandparents	-3.64	2.493	2.13	1	0.14	0.026	0	3.482
DM family history= Second degree relatives	-1.06	1.23	0.741	1	0.39	0.347	0.03	3.988
Current FBS=5.7 to 8.6	3.77	2.987	1.593	1	0.21	43.401	0.124	15145.428
Current FBS= More than 8.6	-5.98	2.23	7.198	1	0.01	0.003	0	0.453
Avg FBS=5.7 to 8.6	-0.94	0.896	1.107	1	0.29	0.39	0.067	2.277
Avg FBS= More than 8.6	0.76	0.889	0.722	1	0.4	2.129	0.359	12.625
Avg 2HABS=7.7 to 10.6	-1.22	0.941	1.681	1	0.2	0.295	0.045	1.923
Avg 2HABS= more than 10.6	-0.68	1.347	0.253	1	0.62	0.508	0.036	7.111
HbA1C=6.7 to 9.6	-4.82	2.443	3.895	1	0.05	0.008	0	0.968
HbA1C= more than 9.6	-4	2.041	3.842	1	0.05	0.018	0	1

Several glycemic control parameters also show significant protective effects. Compared to the lowest fasting blood sugar (FBS <5.7 mmol/L), FBS levels of 6.7–7.6 mmol/L (OR=0.003, p=0.01), 7.7–8.6 mmol/L (OR=0.009, p=0.02), and 9.7–10.6 mmol/L (OR=0.04, p=0.04) are associated with drastically lower odds of inadequate FHL, indicating that moderately elevated FBS paradoxically correlates with better literacy. Similarly, a three-month mean postprandial glucose of 8.7–9.6 mmol/L reduces odds to near zero (OR=0.000, p<0.001). HbA1c levels of 6.7–8.6% (OR=0.008, p=0.05) and 8.7–9.6% (OR=0.018, p=0.05) also lower the likelihood of inadequate FHL. A family history of diabetes among siblings is significantly protective (OR=0.023, p=0.05). Education, occupation, income, physical activity, and treatment regimen show no significant independent effects in this model.

Discussion

This study investigated the associations between Functional Health Literacy (FHL) and glycemic control, lifestyle factors, sleep duration, and socio-demographic characteristics among women with Type 2 Diabetes. The findings indicate that socio-economic factors, including education level, economic status, and occupation, were significantly associated with



FHL, supporting previous research indicating education and income are strong predictors of FHL in chronic illness populations (5). Notably, no significant associations were observed with other demographic factors such as marital status or residential area, though the urban majority in our sample may reflect broader patterns of healthcare access (15,16), with rural populations often facing structural barriers to health information and care (17).

Assessment of FHL levels revealed a high prevalence of limited literacy, with around quarter of them had adequate level, a distribution consistent with other studies (16) and indicative of substantial challenges in health awareness among diabetic patients (18). Several lifestyle factors demonstrated statistically significant correlations with FHL, including physical activity, job type, mode of transportation, and social media use. International studies have found a significant connection between physical activity and health literacy. Buja et al. (2020) found that lower health literacy is consistently associated with lower levels of physical activity across a number of the population. This shows that health literacy-focused treatments may have unintended consequences for encouraging physical exercise (19).

The study revealed a significant association between social media use and FHL. Only a few (15.2%) of participants who used social media for less than two hours each day had low FHL, compared to double of those who never used it. According to a Turkish study by Kılınc İşleyen & Özdemir (2025), diabetes patients who use the internet on a daily basis had significantly higher e-health literacy scores, with a substantial proportion accessed health information through the internet or social media (20). The association between moderate social media use and better FHL further suggests a potential role for digital health communication (21). In contrast, no significant associations were found with alcohol, tobacco, or television use—a deviation from different social contexts possibly reflecting cultural and religious norms (22,23).

Sleep behavior emerged as a particularly strong predictor: both sleep duration and sleep quality were significantly associated with FHL. Regression analysis confirmed that shorter sleep duration drastically increased the odds of inadequate FHL and marginal FHL, possibly due to mechanisms such as diminished capacity to process and retain health-related information, a shorter attention span, or altered cognitive function. This findings aligning with evidence that poor sleep adversely affects diabetes self-management and mental health



(24,25). Sleep and diabetes self-management are known to be related. According to global guidelines, getting enough sleep is one of the most critical aspects of diabetic lifestyle management (26). Hu et al. (2022) found that sleep duration and quality influence metabolic management, cognitive performance, and overall well-being (27). The current study demonstrating that lower FHL is independently associated with shorter sleep duration in female diabetic patients in Bangladesh. This conclusion suggests that sleep quality may need to be addressed in treatments targeted at promoting health literacy, or that insufficient sleep may impair the cognitive processes required for interpreting and implementing health information(28).

Glycemic measures were strongly correlated with FHL including current FBS, three-month mean FBS, 2HABFS, and HbA1c, all showed significant associations. Multivariate analysis indicated that women with moderately or poorly controlled blood sugar levels (e.g., fasting blood sugar between 7.1–13.9 mmol/L) were actually less likely to have inadequate functional health literacy compared to those with well-controlled blood sugar levels. This unexpected pattern was also seen with HbA1c and 3-months' mean 2HABS levels, where higher glucose values were linked to better FHL scores (Table 6). These results reinforce the well-established link between inadequate FHL and poor glycemic control (29,30), possibly mediated through factors such as treatment adherence and self-management capabilities. Although, this contradictory correlation could be explained by the fact that women with better glycemic management have more severe personal glucose goals and hence perceive their literacy as inadequate in comparison to their higher expectations (31).

Female diabetic patients at risk of inadequate glycemic control can be identified through routine screening for insufficient functional health literacy (FHL) with simple tools such as S-TOFHLA(4). Sleep duration should be assessed as part of integrated diabetes management guidelines, since less than six hours of sleep is an independent predictor of insufficient FHL and may necessitate education on proper sleep habits(26). According to study, health literacy treatments that focus on modifiable lifestyle factors, such as physical activity promotion and social media-based health information dissemination, provide potential solutions(32). Finally, to address the disproportionate burden of inadequate FHL in this vulnerable community,



diabetic self-management programs should prioritize women with little income and education, using teach-back approaches, visual aids, and simple language(33,34).

A cultural preference for oral anti-diabetic agents over insulin, often rooted in fear and misinformation, may contribute to suboptimal glycemic outcomes in women with limited FHL (11). From a policy perspective, the Ministry of Health and Family Welfare should develop culturally relevant, literacy-sensitive educational program (35) through easily accessible platforms such as social media, and incorporate fast FHL screening into routine diabetes care for women (36). The findings underscore the importance of developing literacy-sensitive education strategies to improve long-term glycemic control and reduce complications(37).Therefore, policymakers should prioritize low-income, less educated women by implementing scalable efforts such as teach-back approaches, visual aids, and plain-language resources (38).

Study Limitations and Strengths: This study acknowledges several methodological limitations. Furthermore, the cross-sectional design inherently precludes the establishment of causal inferences between functional health literacy (FHL) and the associated variables. The reliance on self-reported data for lifestyle and sleep-related factors introduces the potential for biases, including social desirability bias and recall error. Purposive sampling was used to include participants from follow-up visits to only three selected diabetic centers, may have resulted in a selection bias by over-representing individuals engaged in proactive healthcare practices. This limits the data's generalization to the larger population of female diabetes patients in Bangladesh, particularly those who live in rural areas or do not regularly attend follow-up visits. A potential measurement limitation is noted regarding the administration of the S-TOFHLA; although explained in Bengali, which may have disproportionately affected the performance of less literate respondents. Lastly, to determine the sincere findings, a thorough comparison study had to be carried out.

Conclusion

This study reveals critically low functional health literacy (FHL) among the population, with only one-quarter demonstrating adequate levels. FHL is significantly associated with sociodemographic factors (education, occupation, income), modifiable lifestyle behaviors (physical activity, job type, transport), and notably, sleep duration. Clinically, robust associations between FHL and glycemic indicators like HbA1c, fasting blood glucose, and



postprandial glucose are evident. Multivariate analysis indicates a complex relationship wherein poorer glycemic control correlates with higher risk of inadequate FHL, though causal directionality requires further investigation. These findings underscore an urgent need to move beyond conventional patient education toward comprehensive, multi-faceted interventions. Clinical protocols should integrate routine sleep assessment with literacy-appropriate glycemic education, particularly for female patients with type-2 diabetes in Bangladesh. Future longitudinal research is essential to evaluate the long-term efficacy of such health literacy strategies on sustained glycemic control and quality of life.

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