Original Paper

Evaluating Health Literacy In Patients with Type 2 Diabetes Treated in Primary Health Care in the Attica Region of Greece

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ABSTRACT: Background: Effective management of Type 2 Diabetes Mellitus (T2DM) requires high health literacy (HL). This study evaluated the multidimensional HL of patients with T2DM in Primary Health Care (PHC) structures in Greece, which serve as the first point of contact for DM management. Methodology: This quantitative, cross-sectional study included 201 patients from PHC structures in Attica. Participants completed the Literacy Assessment Scale for Diabetes (LAD), the Diabetes Knowledge Test (DKT), and the Diabetes Numeracy Test-5 (DNT-5). Results: Participants demonstrated high oral reading ability (LAD mean: 57.8) but moderate diabetes knowledge (DKT mean: 9.0) and numeracy (DNT-5 mean: 2.0). Statistically significant moderate positive correlations were found between all three scales ($p<0.001$), with the strongest relationship between knowledge and numeracy ($r=0.56$). Educational level was the most robust positive predictor across all domains. Conversely, increased age and comorbidities significantly hindered numeracy skills. Patients living with DM for more than five years demonstrated significantly higher DKT and DNT-5 scores in the adjusted models. Conclusions: A significant gap exists between basic reading ability and diabetes comprehension. PHC models should shift from physician-centric information delivery to multidisciplinary, interactive approaches, to ensure patient understanding and improve self-management outcomes.

KEYWORDS: *Type 2 Diabetes, primary health care, health literacy, knowledge, numeracy.*

Introduction

Diabetes mellitus (DM) is a complex chronic condition characterized by elevated blood glucose levels resulting from the body's inability to produce or effectively use insulin. Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic condition characterized by elevated blood glucose levels, which occur when the body becomes resistant to insulin or the pancreas is unable to produce enough insulin to maintain normal levels [1].

T2DM requires active patient participation, consistent daily management [2], and high levels of functional health literacy for successful management.

Effective management of DM relies heavily on patient education and the ability to navigate medical information to prevent long-term complications [3].

Health Literacy (HL) includes the cognitive and social abilities that influence a person's motivation and capacity to obtain, comprehend, and utilize information in manners that foster and sustain good health.

Concurrently, HL serves as a tool for the advancement of both individuals and society at large, as it enhances citizens' access to health-related information and their proficiency in applying it [4].

HL in this context of DM is multidimensional, encompassing the ability to articulate medical terms, possess general knowledge of the disease, and apply numeracy skills for daily tasks like medication dosing [5].

Primary Health Care (PHC) is an approach that combines health interventions at both the population and individual levels, transitioning from a reactive approach to illness towards a more comprehensive and proactive strategy for health and well-being [6].

In the Greek healthcare system, PHC is mainly delivered by the public sector via rural and urban healthcare centers, in addition to the private sector, which encompasses private clinics located in urban and semi-urban regions [7].

PHC structures, such as public healthcare centers, serve as the essential first point of contact for routine monitoring and patient education.

These facilities are vital for the long-term management of chronic conditions, aiming to provide accessible care that prevents complications and reduces the burden on secondary hospital services and ensuring continuity of care [8].

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Beyond the clinical setting, the effectiveness of care is deeply rooted in the patient's ability to navigate the healthcare system and comprehend medical instructions and apply self-care measures [9].

HL serves as the foundation for this interaction, as it determines how well an individual can process health information to make informed decisions and maintain their wellbeing [10].

The general gap that exists in DM management, as well as the primary motivation for this research, lies in the gap between access to information and functional understanding; particularly critical in DM because it requires a high level of knowledge, daily technical and numerical precision [11].

This gap is driven by information overload, emotional burden, and a lack of tailored, actionable, and timely education in DM patients [12].

Objective

This study aimed to evaluate health literacy, knowledge, and numeracy among patients with T2DM treated in PHC health centers in the Attica region.

Methods

Setting and Sample

This was a quantitative, cross-sectional study, based on measurement scales, conducted from 2022-2024.

Patients with T2DM (n=201) were recruited through convenience sampling from those attending the outpatient Health Centers of PHC structures in Attica.

The study included adult participants (aged 18 years and older), who have been diagnosed with T2DM.

A prerequisite for participation is that the diagnosis of the disease has been made at least one year before the start of the research.

In addition, participants should have the ability to speak and read the Greek language satisfactorily, in order to ensure proper understanding of the procedure.

Individuals under the age of 18 were excluded from the sample, as well as those who present mental or psychiatric disorders, that could affect the validity of the results.

Also individuals with sensory disorders (such as severe hearing or vision problems) that make communication difficult were excluded, as well as those who did not speak or did not adequately understand the Greek language.

Measurements

At first participants completed a form created for the needs of the research, to collect demographic and socio-economic characteristics, health behaviors related to T2DM and comorbidity.

Then, participants completed the Literacy Assessment Scale for diabetes (LAD), the Diabetes Knowledge Test (DKT) and the Diabetes Numeracy Test-5 (DNT-5).

The LAD serves as a tool for evaluating health literacy (HL) among patients with DM.

It is specifically designed to assess the verbal capabilities of individuals with DM in articulating words of varying difficulty levels.

These words pertain to terms and concepts that are frequently encountered in everyday life and are particularly relevant to the management of DM.

The LAD scale comprises 60 words organized into three columns, each representing a different level of difficulty and increasing complexity, which participants are required to pronounce.

Words pronounced correctly are counted as correct responses and assigned a score of 1, while those pronounced incorrectly receive a score of 0.

The raw score is determined by aggregating the scores from the three word lists, reflecting the number of words pronounced correctly.

This total score is subsequently converted to a reading grade level using the conversion table included in the tool's score sheet.

The LAD score can range from 1 to 60, depending on the number of words pronounced correctly.

The scoring system is ordinal and does not utilize a Likert scale.

Finally, the total score is classified into three categories according to the original LAD framework: 1-20 (low level), 21-40 (moderate level), and 41-60 (high level) [13].

It was translated and validated into Greek, including three subscales pronunciation, knowledge, and comprehension [14].

The Kuder-Richardson reliability coefficient for the LAD was 0.800, indicating excellent reliability of the questionnaire.

The revised DKT consists of 20 statements about the DM which the participant must read and indicate for each one whether he believes it is true or false and in case he does not know, to

state it by selecting the indication: I do not know.

The 20 questions in this format represent a test of general knowledge about DM and includes nutrition and ingredients (items 1, 3, 4, 6, 8, 13), glycemic control and testing (items 2, 5, 16), management of hypoglycemia and complications (items 7, 14, 15, 19, 20), lifestyle and physical condition (items 9, 10), factors affecting glucose (items 11, 12), and insulin use (items 17, 18) [15].

The Kuder-Richardson reliability coefficient for the DKT was 0.600, indicating acceptable reliability of the questionnaire.

The DNT-5 is an abbreviation for the Diabetes Numeracy Test (DNT).

This version of the scale includes five statements and can be used to assess the numeracy skills necessary for diabetes self-management.

The statements refer to portion calculation, nutrition label reading, carbohydrate adjustment for exercise, consumables planning, and insulin dose calculation.

Items are evaluated based on binary results-either correct or incorrect-with no allowance for partial credit.

There is no time constraint for administering the scale.

Performance on the DNT-5 is correlated with diabetes knowledge, self-efficacy, health behaviors, and glycemic control [16].

The Kuder-Richardson reliability coefficient for the DNT-5 was 0.830, indicating excellent reliability of the questionnaire.

Statistical analysis

Categorical variables were presented as absolute and relative frequencies, while quantitative variables are presented as mean, standard deviation, median, minimum and maximum.

The Kolmogorov-Smirnov test was used to test the normal distribution of quantitative variables.

To investigate the relationship between the independent variables and the dependent variables, bivariate regression was performed and then a multivariate regression.

With multivariate regression, confounding effects are also eliminated and therefore the conclusions are based on multivariate analysis.

More specifically, linear regression was applied, as the dependent variables were quantitative variables.

In this case, we present the b coefficients, the corresponding 95% confidence intervals and the p values.

To investigate the correlations between the scales, the Pearson correlation coefficient was used.

Insurance could not be included in the correlations due to limited variability.

The two-sided statistical significance level was set at 0.05.

Data analysis was performed with SPSS 21.0 (IBM Corporation, Somers, Armonk, NY, USA).

Ethics

During the research, all ethical and moral rules were applied and all personal data protection measures were taken.

The research team collected and processed the personal data of the participants, which were used exclusively for the purposes of this research.

The questionnaires were completed under the responsibility of the primary researcher, after the participants have been fully informed about the method of completing them and the purpose of the research and after they have been assured that the data they will provide will be used exclusively for the purposes of this study, with respect to the legislation on the protection of personal data.

All participants signed an informed consent form to participate in the study.

Results

Sample's characteristics

The sample consisted primarily of elderly individuals with an average age of 65.5 years, a majority of whom were women (60.2%) and retirees (56.2%).

There was a high percentage of public insurance coverage (84.1%) and a predominantly middle-to-low income profile.

Regarding their clinical profile, over half of the participants (52.3%) have been living with DM for 2 to 5 years.

Cardiovascular diseases (23.4%) were the most prevalent comorbidities among the sample.

In terms of health management, while 41.8% engage in physical exercise, obesity remains high at 39.3%, and only 29.4% report following a healthy diet.

Finally, the treating physician is the primary source of information (98%), followed by other healthcare professionals (46.3%) (Table 1).

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Table 1. Sample's characteristics.

Characteristics	Mean	SD
Age	65.5	14.1
Gender	**N**	**%**
Men	80	39.8
Women	121	60.2
Marital Status		
Single	20	10
Married/In Cohabitation	111	55.2
Divorced/Separated	36	17.9
Widowed	34	16.9
Living Status		
Alone	67	33.3
With family	134	66.7
Education level		
Compulsory	89	44.3
Secondary	68	33.8
Tertiary	40	19.9
Postgraduate/Doctorate	4	2
Occupation		
Private sector employees	20	10
Public sector employees	32	15.9
Self-employed	8	4
Retirees	113	56.2
Housework	24	11.9
Unemployed	4	2
Insurance		
Public	169	84.1
Private	4	2
Both	24	11.9
None	4	2
Annual income (€)		
< 5,000	8	4
5,000-10,000	75	37.3
10,001-30,000	114	56.7
> 30,000	4	2
Years with DM		
2-5 years	103	52.3
6-10 years	29	14.7
> 10 years	65	33
Common comorbidities		
Cardiovascular diseases	47	23.4
Diabetic retinopathy	39	19.4
Dyslipidemia	35	17.4
Diabetic neuropathy	19	9.5
Thyroid disease	18	9
Diabetic nephropathy	8	4
Osteoporosis	8	4
Other	8	4
Health behaviors		
Physical exercise	84	41.8
Obesity	79	39.3
Smoking	73	36.3
Sedentary lifestyle	70	34.8
Healthy diet	59	29.4
Information sources		
Physician	197	98
Nurses/Other Healthcare Professionals	93	46.3
Internet	48	23.9
Social environment	45	22.4

Descriptive characteristics

The LAD mean score was 57.8 and the standard deviation was 2.6.

All the participants had a score >40, indicating a high level of oral reading ability for words related to diabetes.

The DKT mean score was 9 and the standard deviation was 2.7.

The mean score on the DKT indicates a moderate level of knowledge about diabetes. The DNT-5 mean score was 2 and the standard deviation was 1.8.

The mean score on the DNT-5 indicates a moderate level of numeracy for diabetes (Table 2).

Table 2. Descriptive characteristics.

Assessment Scale	Mean	SD	Median	Range (Min-Max)
LAD	57.8	2.6	59	50-60
DKT	9.0	2.7	9	0-13
DNT-5	2.0	1.8	1	0-5

Correlations between measurement scales

As shown in Table 3, there was a statistically significant, moderate positive correlations between all three scales (p<0.001).

The strongest relationship was observed between general diabetes knowledge (DKT) and diabetes-related numeracy (DNT-5), with a coefficient of r=0.56.

Additionally, LAD showed strong associations with both knowledge (r=0.53) and numeracy (r=0.50), suggesting that higher literacy levels in these patients are closely linked to better comprehension and calculation skills related to their condition.

Table 3. Pearson correlation coefficients between scales.

Variables		LAD	DKT	DNT-5
LAD	r	1	**0.53**	**0.50**
	p-value	-	<0.001	<0.001
DKT	r		1	**0.56**
	p-value		-	<0.001
DNT-5	r			1
	p-value			-

r: Pearson correlation coefficient.
Statistical significance set at p <0.05.

Dependent variable: LAD

To investigate the relationship between the independent variables and the LAD scale, bivariate linear regression was first performed and then multivariate linear regression was performed to eliminate confounders. The results of this analysis are presented in Table 4.

Age remained a significant negative predictor, where LAD scores decreased as age increased (b=-0.11, p<0.001).

Education had the strongest positive impact; compared to compulsory education, both secondary (b=2.76) and tertiary education (b=3.11) significantly increasing LAD scores (p<0.001).

Living with family was associated with lower LAD scores in the adjusted model (b=-1.70, p<0.001).

While employment initially showed a positive correlation, it shifted to a negative coefficient in the multivariate model (b=-2.13, p<0.001), suggesting that other underlying factors (like age or education) influence this relationship.

Gender also emerged as significant in the adjusted model, with women scoring slightly higher than men (b=0.69, p=0.01).

Table 4. Bivariate and multivariate linear regression with LAD as the dependent variable.

Independent Variables	Bivariate Linear Regression Unadjusted Coefficient b	95% Confidence Interval	p-value	Multivariate Linear Regression Adjusted Coefficient b	95% Confidence Interval	p-value
Female (vs. Male)	0.02	-0.72 to 0.77	0.95	0.69	0.15 to 1.22	0.01
Age	-0.10	-0.12 to -0.08	<0.001	-0.11	-0.14 to -0.07	<0.001
Married (vs. Single /Divorced/Widowed)	-0.09	-0.82 to 0.64	0.81	0.08	-0.69 to 0.84	0.84
Living with family (vs. Alone)	-0.58	-1.34 to 0.19	0.14	-1.70	-2.46 to -0.93	<0.001
Education Level						
Secondary (vs. Compulsory)	1.80	1.07 to 2.52	<0.001	2.76	2.06 to 3.46	<0.001
Tertiary (vs. Compulsory)	2.88	2.10 to 3.66	<0.001	3.11	2.09 to 4.12	<0.001
Employed (vs. Unemployed)	2.35	1.63 to 3.07	<0.001	-2.13	-3.07 to -1.18	<0.001

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Annual Income >€10,000 (vs. ≤€10,000)	2.16	1.49 to 2.84	<0.001	-0.23	-0.91 to 0.45	0.50
>5 years with DM (vs. ≤5 years)	-1.49	-2.20 to -0.78	<0.001	0.03	-0.65 to 0.70	0.94
Number of comorbidities	-0.20	-0.52 to 0.12	0.21	0.08	-0.17 to 0.33	0.54
Smoking	0.15	-0.60 to 0.91	0.69	0.08	-0.57 to 0.74	0.80

Dependent variable: DKT

Likewise, bivariate linear regression and multivariate linear regression conducted to investigate the relationship between the independent variables and DKT (Table 5).

Gender became highly significant in the adjusted model, with women showing higher DKT scores (b=1.62, p<0.001).

Additionally, higher education levels (Secondary b=2.56; Tertiary b=4.10) and being employed (b=2.96) were strong positive predictors of DKT.

Patients living with diabetes for more than five years showed significantly higher DKT scores in the adjusted model (b=2.95, p<0.001).

Obesity (b=1.91, p<0.001) and adherence to a healthy diet (b=0.95, p=0.02) were also associated with higher DKT scores and an annual income exceeding €10.000 was a positive predictor of better DKT scores (b=1.18, p=0.002).

Table 5. Bivariate and multivariate linear regression with DKT as the dependent variable.

Independent Variables	Bivariate Linear Regression Unadjusted Coefficient b	95% Confidence Interval	p-value	Multivariate Linear Regression Adjusted Coefficient b	95% Confidence Interval	p-value
Female (vs. Male)	-0.07	-0.85 to 0.72	0.87	1.62	1.03 to 2.22	<0.001
Age	-0.09	-0.11 to -0.07	<0.001	0.03	-0.01 to 0.08	0.14
Married (vs. Single/Divorced/Widowed)	-0.25	-1.02 to 0.52	0.52	-0.51	-1.36 to 0.34	0.24
Living with family (vs. Alone)	-0.08	-0.89 to 0.72	0.84	-0.81	-1.67 to 0.04	0.06
Education Level						
Secondary (vs. Compulsory)	1.02	0.22 to 1.81	0.01	2.56	1.79 to 3.34	<0.001
Tertiary (vs. Compulsory)	3.51	2.73 to 4.30	<0.001	4.10	2.97 to 5.22	<0.001
Employed (vs. Not working)	2.69	1.95 to 3.44	<0.001	2.96	1.91 to 4.01	<0.001
Annual Income >€10,000 (vs.≤€10,000)	2.42	1.72 to 3.12	<0.001	1.18	0.42 to 1.93	0.002
>5 years with Diabetes (vs.≤5years)	-0.49	-1.26 to 0.29	0.22	2.95	2.21 to 3.70	<0.001
Number of Comorbidities	-0.12	-0.46 to 0.22	0.48	0.10	-0.18 to 0.38	0.48
Smoking	-0.37	-1.16 to 0.43	0.36	-0.36	-1.09 to 0.37	0.34
Obesity	1.21	0.45 to 1.98	0.002	1.91	1.19 to 2.62	<0.001
Sedentary Lifestyle	0.19	-0.61 to 0.99	0.64	-0.60	-1.31 to 0.11	0.10
Physical Exercise	2.03	1.31 to 2.75	<0.001	0.01	-0.73 to 0.74	0.98
Healthy Diet	0.71	-0.13 to 1.54	0.10	0.95	0.15 to 1.76	0.02
Information from Nurses/Healthcare professionals	1.46	0.72 to 2.20	<0.001	0.33	-0.24 to 0.89	0.25

Dependent variable: DNT

Similarly, bivariate linear regression and multivariate linear regression was performed (Table 6) to investigate the relationship between the independent variables and DNT.

Female gender (b=0.43, p=0.02) and higher education (Secondary b=0.68, p=0.004; Tertiary b=2.51, p<0.001) were associated with higher DNT scores.

Conversely, increased age (b=-0.04, p=0.01) and being married b=-1.25, p<0.001) were negative predictors of DNT.

Patients with a diabetes diagnosis exceeding five years demonstrated better DNT (b=0.59, p=0.01), as did those with an annual income above €10,000 (b=0.98, p <0.001).

A higher number of comorbidities was a strong negative predictor, significantly lowering DNT (b=-0.39, p <0.001)

Table 6. Bivariate and multivariate linear regression with DNT as the dependent variable.

Independent Variables	Bivariate Linear Regression Unadjusted Coefficient b	95% Confidence Interval	p-value	Multivariate Linear Regression Adjusted Coefficient b	95% Confidence Interval	p-value
Female (vs. Male)	-0.03	-0.55 to 0.45	0.92	0.43	0.08 to 0.78	0.02
Age	-0.08	-0.10 to-0.07	<0.001	-0.04	-0.06 to-0.01	0.01
Married (vs. Other)	-0.45	-0.96 to 0.06	0.08	-1.25	-1.75 to-0.75	<0.001
Living with family (vs. Alone)	-0.29	-0.83 to 0.25	0.29	0.12	-0.39 to 0.62	0.65
Education Level						
Secondary (vs. Compulsory)	-0.40	-0.94 to 0.14	0.15	0.68	0.22 to 1.14	0.004
Tertiary (vs. Compulsory)	3.28	2.86 to 3.70	<0.001	2.51	1.85 to 3.18	<0.001
Employed (vs. Not working)	2.33	1.87 to 2.78	<0.001	0.11	-0.51 to 0.73	0.73
Annual Income >€10,000	1.84	1.39 to 2.29	<0.001	0.98	0.53 to 1.42	<0.001
>5 years with Diabetes	-1.50	-1.97 to -1.02	<0.001	0.59	0.15 to 1.03	0.01
Number of Comorbidities	-0.57	-0.78 to -0.36	<0.001	-0.39	-0.55 to -0.23	<0.001
Smoking	-0.11	-0.64 to 0.43	0.70	-0.32	-0.75 to 0.11	0.14
Obesity	-0.16	-0.69 to 0.36	0.54	-0.27	-0.69 to 0.16	0.21
Sedentary Lifestyle	-0.59	-1.12 to -0.06	0.03	-0.06	-0.48 to 0.36	0.77
Physical Exercise	0.93	0.42 to 1.43	<0.001	-0.46	-0.89 to 0.03	0.06
Healthy Diet	0.84	0.29 to 1.39	0.003	0.10	-0.38 to 0.58	0.67
Information from Nurses/Healthcare professionals	-0.01	-0.53 to 0.50	0.96	-0.15	-0.48 to 0.18	0.38

Discussion

Findings highlight a significant disparity between basic literacy and functional diabetes-related skills among patients with T2DM.

While participants demonstrated a high level of oral reading ability, their actual diabetes knowledge and numeracy skills remained at a moderate level.

These findings suggest that being able to read medical terms does not necessarily equate to understanding the technical information or the numerical calculations required for effective self-management.

Research indicates that even when patients can read the words, they often misunderstand, and addressing this requires tailored education, simplifying medical jargon, and improving patient numeracy skills [17].

The impact of problematic numeracy in managing health conditions is documented.

Low numeracy negatively impacts health outcomes by distorting the perception of medical risks and benefits, which reduces medication compliance and obstructs access to effective treatments.

Furthermore, individuals with limited numeracy skills are more vulnerable to extraneous factors and decision-making biases, which undermines their capacity to make informed medical choices [18-20].

Adequate HL and numeracy are crucial for DM care, as they are directly associated with improved self-monitoring of blood glucose practices, correct calculation of insulin doses and the interpretation of glucometer readings.

Limited HL and numeracy are often associated with poorer glycemic control [21].

In relation to numeracy, the research suggests moving from complex percentages to simple frequencies and using visual aids to reduce cognitive load on patients [22].

At the same time, it is necessary to incorporate tools such as digital dose calculators and the “teach-back” method to ensure accuracy of calculations in daily diabetes self-management [23].

Despite the accessibility of PHC professionals, results reveal this significant gap in functional health literacy. Similar to our findings, the study by Kostagiolas et al. (2023), conducted at a PHC facility in Attica with 102 people, found high reading ability that did not match functional knowledge.

This study found that patients had low levels of digital health literacy and skills for finding and utilizing medical information [24].

The study of Michou et al. (2019) in Attica with 1281 individuals with chronic diseases, also recorded problematic levels of general HL, with 41.2% of the sample falling into the "problematic" category [25].

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Possibly, the current PHC model may prioritize the delivery of information over the verification of patient comprehension, as evidenced by the moderate scores in DKT and DNT-5.

Our results of moderate knowledge despite good reading, are in line with the qualitative findings of de Wit et al. (2020), highlighting that in Greece, PHC requires a culture change; from simply providing instructions by the doctor, to actively verifying understanding [26].

Following, the regression analysis identified education level as the most robust positive predictor across all domains of health literacy and knowledge.

Conversely, increased age and the presence of multiple comorbidities emerged as significant barriers to mastering the numeracy skills essential for diabetes care.

The results are in complete agreement with Michou et al. (2019), where education was the dominant factor that positively influenced literacy, but the negative effect of chronic disease on HL disappeared when controlling for education level [25].

Education acts as a protective shield, enhancing HL, which in turn improves self-care, glycemic control, and overall quality of life while reducing complications [27].

Then, patients in our sample with more comorbidities had significantly lower numeracy, which makes diabetes management more difficult. Similar, Michou et al. (2019) showed that patients with at least one chronic disease had significantly lower health and nutrition literacy compared to healthy individuals [25].

This is a vicious cycle. Low HL prevents the adoption of a healthy diet and exercise (as seen in the sample where only 29.4% follow a healthy diet), increasing the risk of developing and worsening chronic diseases [28].

Also, the study by Kostagiolas et al. (2021) specifically investigated the information-seeking behavior of 106 patients with T2DM treated in outpatient major university hospital’s clinics in Athens.

They noticed that as the disease progresses, there is a clear shift in needs.

More years since diagnosis were positively correlated with a need for information on diabetes medication, while interest in diabetes pathogenesis decreased [29].

This aligns with our finding that patients with a longer duration of DM may possess more specific knowledge (DKT) and numeracy skills (DNT-5) because their informational focus has shifted toward technical management.

Similar to our results, the complexity of treatment and presence of other issues were linked to increased difficulty in accessing and understanding information.

Furthermore, a qualitative study was conducted in less-privileged urban neighborhoods with relatively high levels of socioeconomic deprivation in Athens, involving individuals aged 50 years and older.

Older people often had difficulty in understanding medical terminology and instructions, feeling that they "don't speak the same language" as doctors [26].

Also, the demographic determinants in another study in PHC in Attica strongly mirror our own results. Increasing age and the presence of chronic disease were significant predictors of lower information literacy.

Lower educational levels and poor financial status were consistently linked to decreased skills in seeking and evaluating health information [24].

Overall, key determinants of HL in patients with T2DM, include a patient's diabetes-related knowledge and general literacy, but the influence of gender differences and the organizational environment on HL levels remains poorly understood and requires further research [30].

To note that, The strong positive correlation between health literacy, numeracy, and diabetes knowledge highlights their interdependence in diabetes self-management, as an improvement in one area likely bolsters the others.

Patients with higher literacy and numeracy skills generally possess greater disease knowledge, which directly translates to improved glycemic control and better self-care, such as improved medication adherence [31], and accurate blood glucose monitoring [32].

When patients better understand written materials (literacy) and can accurately calculate insulin/food ratios (numeracy), their confidence to manage their disease increases, leading to better self-care behaviors [33,34].

Targeted interventions for enhancing literacy, numeracy, and diabetes knowledge from interdisciplinary teams is mandatory for better patient outcomes [17].

Moreover, the treating physician was the near-universal primary source of information for patients, cited by 98% of the sample.

While this indicates a high level of trust and a clear point of contact, it also suggests that the

organization of care relies almost entirely on the doctor-patient relationship rather than a broader healthcare team.

The Greek system is heavily physician-centered. Greece has a tradition of family medicine, and a significant number of Greeks have access to a primary care physician who offers them continuous care and assistance [24,35].

In a study, older adults with T2DM and healthcare professionals reported that communication is highly doctor-centric.

Patients rely almost exclusively on their personal doctor for information and guidance [26].

Also physicians were the most important information source by another study, and nurses were ranked lower [29], echoing our finding where 46.3% of our participants received information from nurses or other healthcare professionals.

This indicates that while nurses are present in PHC settings, their role in structured diabetes education and literacy support may be underutilized.

In Greece, although the economic crisis had an impact, patients focused more on the personal relationship with the doctor as a means of overcoming obstacles [26].

So, HL is not just a matter of "individual abilities" (how well someone can read or calculate), but a matter of system requirements.

When the system (especially in Greece) is chaotic and doctor-centric [35], elderly people with low literacy are possibly marginalized [26].

Given that the treating physician and then nurses or other healthcare professionals were the reported sources of information, there is a critical opportunity for targeted educational interventions.

This high level of trust highlights the central role of PHC providers play in patient education and guidance.

Clinical practice should move beyond providing simple written instructions and focus on enhancing functional numeracy and comprehension, particularly for older patients and those with lower educational backgrounds.

Implementing "teach-back" methods and simplified numerical tools could bridge the gap between high reading ability and moderate functional understanding, ultimately improving health outcomes for patients with T2DM [17,36].

Unlike our results, Kostagiolas et al. (2023) found that the most frequent information sources were the media (television, radio).

In their results, medical and nursing staff was ranked significantly lower as information sources compared to traditional media or family/friends [24].

While patients in our study relied heavily on doctors, another PHC population in Attica may still be heavily influenced by passive media sources, reinforcing the need for more active teaching methods to ensure accurate understanding.

Primary Health Care in Greece is provided through a network of public health centers and outpatient clinics.

Patients with T2DM typically access these structures for routine monitoring, prescriptions, and basic education.

The study reflects this organization, as participants were recruited directly from these structures.

The study's demographic profile; predominantly elderly, retired individuals with middle-to-low income and public insurance coverage, aligns with the typical population utilizing public PHC structures in Greece [37].

The results indicate that these structures are dealing with a population facing significant self-management barriers, such as high rates of obesity (39.3%) and a low adherence to a healthy diet (29.4%).

As reported in a study in rural PHC structures in Greece, chronically ill people were dramatically less satisfied with the organization of care and clinical behavior compared to healthy people.

PHC organization in Greece is better at clinical monitoring than at supporting behavioral change and self-management, as behavior change skills need more attention for an effective primary care model [38].

This underscores the need for Greek PHC settings to move beyond a physician-centric model toward a more integrated, multidisciplinary approach [38,39], that includes specialized nursing [40] and allied health professionals, to support individuals and to improve HL and wellbeing.

Strengths and limitations

A primary strength of this research is the use of validated assessment tools, which allowed for a multidimensional evaluation of the participants' literacy regarding DM management.

By analyzing literacy, general knowledge, and numeracy simultaneously, the study

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provides a more holistic view of the current health education and literacy in diabetes self-management.

Furthermore, the recruitment of 201 participants from Primary Health Care structures in Attica ensures that the findings reflect a real-world population actively seeking outpatient care for T2DM.

The statistical approach, utilized both bivariate and multivariate linear regression.

This is another significant asset, as it allowed for the isolation of true predictors by controlling for confounding variables.

Finally, the high reliability coefficients reported for the scales, particularly for the LAD (0.800) and DNT-5 (0.830), reinforce the technical validity of the data collected.

Despite its strengths, the study has several limitations that should be acknowledged.

First, the cross-sectional design prevents the establishment of causal relationships between the independent variables and the observed levels of literacy or knowledge as it only captures a snapshot in time.

Second, the use of convenience sampling in specific geographical areas of Attica may limit the generalizability of the results to the broader Greek population or to patients living in rural regions.

Another limitation is the moderate reliability of the DKT scale (0.600), which suggests that results regarding general diabetes knowledge should be interpreted with some caution.

Additionally, certain variables, such as insurance status, could not be fully explored in correlation analyses due to a lack of variability within the sample.

Lastly, because the study relied on self-reported health behaviors and socio-economic data, there is a potential for recall bias or social desirability bias among the participants.

Conclusions

Overall, patients with T2DM that received care in primary health care in the Attica region of Greece, demonstrated high oral reading ability, but their actual diabetes knowledge and numeracy skills were found to be moderate.

Future research should focus on longitudinal studies to determine how educational interventions specifically targeting numeracy skills can directly improve long-term diabetes care.

Furthermore, expanding this investigation to primary health care facilities in diverse and distant geographical regions across Greece would enhance the generalizability of these findings and help identify regional disparities in diabetes health literacy.

Ultimately, this research aspires to bridge the gap between basic reading ability and functional medical comprehension in diabetes care.

By identifying that high literacy does not guarantee adequate numeracy or technical knowledge, we aim to advocate for more personalized, patient-centered educational strategies.

We hope these findings will encourage healthcare providers in primary health care to move beyond standard educational methods and adopt more interactive tools, especially for older patients and those with lower educational backgrounds.

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Author Contributions

Conceptualization, M.M., E.V., and A.K.P.; Methodology, M.M., E.V., I.K., and A.K.P.; Investigation, M.M., and A.K.P.; Resources, M.M., and A.K.P.; Data analysis, M.M., E.V., I.K., and I.T.; Manuscript writing and initial draft preparation, E.V., I.K., and I.T.; Manuscript review and editing, I.T; Supervision, A.K.P.

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Conflicts of interest

The authors declare no competing interests.

Institutional Review Board

The study was conducted according to the guidelines of the Declaration of Helsinki; the study and the protocols utilized therein were approved by the responsible ethics and research committee of the 2nd Health Region of Piraeus and Aegean, Ministry of Health, Greece (Approval number No.: 59947; Date: Oct 30th 2019).

Consent Statement

Patients took part in the study after providing written consent and being informed about the research objectives.

Participation was voluntary and anonymous.

Data confidentiality and personal data protection policies were strictly observed

Data availability

All data presented in the manuscript are available from the authors upon request

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