Potential impact of health literacy level on type 2 diabetes risk: A cross-sectional study

Sağlık okuryazarlığı seviyesinin tip 2 diyabet riski üzerindeki potansiyel etkisi: Kesitsel bir çalışma

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Abstract

This study aimed to examine the health literacy (HL) levels of ministry employees, assess their risk of developing type 2 diabetes (T2D), and evaluate the relationship between HL and the risk of developing T2D. Conducted using a cross-sectional design, the study included data from 351 participants working at the Republic of Türkiye Ministry of Environment, Urbanization, and Climate Change between October 2020 and March 2021. Data were collected using the Turkish Health Literacy Scale (TSOY-32) and the Finnish Diabetes Risk Score (FINDRISC). The mean HL score of participants was 31.92±7.85, with 59% of employees classified as having problematic or inadequate HL. Regarding T2D risk, 9.4% of participants were categorized as "*high risk*" and 1.1% as "*very high risk*" for developing T2D within the next 10 years. Descriptive findings indicated that as HL levels decreased, the risk of T2D increased. However, multiple linear regression analysis showed that HL was not independently associated with T2D risk when variables such as age and perceived general health were controlled. These findings suggest that although HL is not a direct determinant of T2D risk, it remains an important factor to consider in diabetes prevention programs due to its association with preventive health behaviors. The high prevalence of low HL among employees highlights the need for systematic assessment and enhancement of HL in workplace diabetes prevention initiatives. Longitudinal studies are necessary to understand better the potential causal relationships between HL and the risk of T2D.

Keywords: Diabetes mellitus, health literacy, occupational health, cross-sectional study

Özet

Bu çalışma, bakanlık çalışanlarının sağlık okuryazarlığı (SOY) düzeylerini ve Tip 2 diyabet (T2D) gelişim risklerini incelemeyi ve SOY ile T2D gelişim riski arasındaki ilişkiyi değerlendirmeyi amaçlamıştır. Kesitsel tasarımda yürütülen çalışma, Ekim 2020–Mart 2021 tarihleri arasında Türkiye Cumhuriyeti Çevre, Şehircilik ve İklim Değişikliği Bakanlığı'nda çalışan 351 katılımcıdan elde edilen verileri kapsamaktadır. Veri toplamada Türkiye Sağlık Okuryazarlığı Ölçeği (TSOY-32) ve Finlandiya Diyabet Risk Skoru (FINDRISC) kullanılmıştır. Katılımcıların SOY ortalama puanı 31,92±7,85 olup çalışanların %59'unun SOY düzeyinin sorunlu/yetersiz olduğu belirlenmiştir. Çalışanların %9,4'ü önümüzdeki 10 yıl içinde T2D geliştirme açısından "*yüksek*", %1,1'i ise "*çok yüksek*" risk grubunda yer almıştır. Tanımlayıcı bulgular SOY düzeyi azaldıkça T2D riskinin arttığını göstermiştir. Ancak çoklu doğrusal regresyon analizinde, yaş ve genel sağlık algısı gibi değişkenler kontrol edildiğinde, SOY'nın T2D riski ile bağımsız bir ilişki göstermediği saptanmıştır. Bu bulgular, SOY'nın doğrudan bir belirleyici olmasa da koruyucu sağlık davranışları ile ilişkisi nedeniyle diyabetten korunma programlarında dikkate alınması gereken bir unsur olduğunu göstermektedir. Çalışanlarda düşük SOY'nın yaygın olması, diyabet önleme girişimlerinde SOY'nın sistematik olarak değerlendirilmesi ve güçlendirilmesi gerektiğini ortaya koymaktadır. SOY ile T2D riski arasındaki potansiyel nedensel ilişkilerin daha iyi anlaşılabilmesi için boylamsal çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Diyabetes mellitus, sağlık okuryazarlığı, iş sağlığı, kesitsel çalışma

Introduction

Health literacy (HL) is defined as "*it is linked to literacy and entails the knowledge, motivation, and competencies to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention, and health promotion to maintain or improve quality of life during the life course*" (1). Although the definition has evolved over time, a more recent and comprehensive description characterizes HL as "*a dynamic, collaborative, and mutually beneficial competency that influences the ability of organizations, caregivers, and healthcare recipients to access, understand, and use health information and services. It encompasses prior health knowledge and experience, individual characteristics, health status, cultural and linguistic preferences, and cognitive abilities, enabling individuals to make informed and actionable decisions to improve health outcomes*" (2). HL mediates the relationship between socioeconomic status, specific health outcomes, use of preventive services, quality of life, and overall health status (3). Within this context, HL is positioned as an independent, identifiable, manageable, modifiable, significant, and critical social determinant of health—one that plays a key role in reducing health inequalities (3, 4).

Diabetes, which accounted for an estimated 1.6 million deaths in 2021, is among the leading causes of mortality worldwide and remains a chronic condition that reduces quality of life in both developed and developing countries; however, its mortality rate can be significantly reduced through early diagnosis (5). Although individuals who are overweight or obese are at particularly elevated risk, a transition from metabolically healthy to unhealthy phenotypes across all body mass index categories increases diabetes risk (6). In a cohort of middle-aged, highly educated adults with initially low BMI and relatively high levels of physical activity, consumption of ultra-processed foods—adjusted for total energy intake—was associated with an increased hazard of developing type 2 diabetes (7). It has also been suggested that lean individuals predisposed to diabetes develop insulin resistance prior to becoming obese, leading to hyperlipidemia and excessive fat accumulation. Emerging evidence suggests that serum ApoB levels and the ApoB/A1 ratio may serve as early predictors of T2D (8), while high-throughput metabolic profiling may detect progressive disruptions in amino acid and lipid metabolism underlying the early etiology of T2D (9). Growing awareness of the determinants of type 2 diabetes risk holds promise for mitigating the clinical and economic burden of diabetes and its related complications. However, awareness alone is insufficient; ongoing monitoring of risk and systematic assessment of risk predictors are essential (10).

Previous studies have shown that HL is important not only as a general level of knowledge but also as a foundation that guides individuals toward preventive health behaviors, such as a healthy diet, regular physical activity, and routine check-ups (11, 12). These findings suggest that HL plays an indirect yet critical role in reducing the risk of T2D. The existing literature indicates that HL influences treatment, care, and various health outcomes (1, 3, 4). In recent years, the relationship between HL and T2D risk in the general population has received increasing attention (12-14); however, evidence remains limited regarding how HL affects T2D risk before disease onset. Therefore, this study aims to examine the effect of HL levels on the risk of T2D among employees of the Ministry of

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Environment, Urbanization, and Climate Change of the Republic of Türkiye, addressing a gap in the current literature.

Research questions and hypotheses

Q1. What is the level of HL among ministry employees?

Q2. What is the developing 10-year risk of T2D among ministry employees?

Q3. Is there a relationship between the HL level and 10-year risk of T2D?

$H0_3$: There is no relationship between HL level and FINDRISC score.

$H1_3$: There is an inverse relationship between HL level and FINDRISC score.

Q4. Is HL independently associated with T2D risk when other risk factors are controlled?

$H0_4$: HL is not independently associated with the FINDRISC score when control variables (age, marital status, perceived general health, presence of chronic disease, etc.) are held constant.

$H1_4$: HL is independently associated with the FINDRISC score when control variables are held constant.

Material and Method

Study design and population

This cross-sectional study was initiated in February 2020 among employees of the Ministry of Environment, Urbanization, and Climate Change of the Republic of Türkiye. However, due to the declaration of the COVID-19 pandemic in March 2020, the planned data collection process was postponed. Data were ultimately collected between October 2020 and March 2021, and analyses were conducted based on data obtained during this period. The study population consisted of a total of 4,000 personnel working at the ministry. The required sample size was calculated using Cochran's (1977) formula for sample size with finite population correction. The formula ($n= N.t^2.p.q / d^2.(N-1)+t^2.p.q$) takes into account the population size (N), the desired confidence level expressed as a t or z value (t), the estimated event prevalence (p) and its complement ($q=1-p$), and the acceptable margin of error (d). This approach first calculates the sample size under the assumption of an infinite population ($n0=t^2.p.q/d^2$) and then applies a finite population correction (15). Assuming an event prevalence of 50%, a 95% confidence interval, and a 5% margin of error, the required sample size was determined to be 351 participants. A systematic sampling method with a fixed interval of 12 was applied using the personnel list. After reaching the end of the list at the 3996th individual (333 × 12), the sampling process was continued in a circular manner by returning to the beginning of the list. The next individual was selected after accounting for the remaining four individuals at the end of the list, and subsequent participants were chosen by maintaining the same sampling interval (e.g., 8th, 20th, 32nd) until the predetermined sample size of 351 participants was reached. Individuals included in the study were over 20 years old, had voluntarily agreed to participate, and had no diagnosis of T2D. Accordingly, a total of 21 individuals were excluded from the study: those under 20 years old (n=2) and those with a diagnosis of T2D (n=19). The study's analyses were conducted with 351 participants.

Procedure and data collection

Data were collected face-to-face. After obtaining verbal consent, the second author (FA), a registered occupational nurse, measured the participants' weight, height, and waist circumference in person. Subsequently, participants completed the personal information form and the study questionnaire via Google Forms.

Instrument and variables

Study data were collected using a "*Personal Information Form,*" the "*Turkish Health Literacy Scale,*" and the "*Finnish Diabetes Risk Score (FINDRISC)*".

The personal information form: This form, developed by the researchers, consists of nine questions that assess participants' socio-demographic and health-related characteristics. The questions include age, gender, marital status, educational level, perceived health status, presence of any chronic illness requiring regular prescription medication, first choice of healthcare facility in case of any health problem or illness, the healthcare facility most frequently used, and the frequency of visits to a healthcare facility in the past month due to any health issue (illness, vaccination, tests, prescription, etc.). In the study, participants' heights were measured without shoes, weights were

measured after removing heavy upper clothing using a standard scale, and waist circumferences were measured with a measuring tape.

Turkish health literacy scale (TSOY-32): The TSOY-32, used to determine participants' HL levels, is a 32-item HL scale developed based on the conceptual framework of the European Health Literacy Survey (HLS-EU) Consortium (16). TSOY-32 has a 4-point Likert-type answer option, coded as very difficult (4), fairly difficult (3), fairly easy (2), and easy (1), while "*do not know*" answers were coded as missing values. The scale is structured as a 2x4 matrix, comprising two main dimensions and four processes. Specifically, the matrix consists of two dimensions (Treatment and services, Disease prevention / health promotion) and four processes (Accessing health-related information, Understanding health-related information, Appraising / evaluating health-related information, Applying / using health-related information), resulting in a total of eight components. Scores on the scale range from 0 to 50. HL levels are categorized based on the total score as follows: 0–25 points: inadequate HL; >25–33 points: problematic/limited HL; >33–42 points: sufficient HL; >42–50 points: excellent HL. Index scores for the matrix components can be calculated if at least 80% of the relevant items are answered. The overall Cronbach's alpha reliability coefficient of the scale was reported as 0.92 (17). In the present study, the Cronbach's alpha reliability coefficient was determined to be 0.94.

Finnish diabetes risk score (FINDRISC): The FINDRISC, developed to identify individuals at risk for type 2 diabetes without the need for laboratory testing, has been validated for use in the Turkish population (18, 19). The Turkish Society of Endocrinology and Metabolism (TEMD) recommends the FINDRISC as a practical tool for diabetes risk screening in Türkiye (20). FINDRISC assesses an individual's risk of developing diabetes mellitus over the next ten years, thereby identifying high-risk individuals and facilitating further diagnostic evaluation. FINDRISC is simple, easy to understand, and evaluates a total of eight parameters: age, body mass index (BMI), waist circumference, daily physical activity, daily consumption of fruits and vegetables, family history of diabetes, presence of hypertension, and whether blood glucose has been previously found elevated incidentally. Points assigned to responses for these parameters are summed to calculate the risk score. The resulting diabetes risk score ranges from 0 to 26. Scores below 7 indicate a "*very low*" 10-year risk of developing T2D; 7–11 indicate a "*low*" risk; 12–14 indicate a "*moderate*" risk; 15–20 indicate a "*high*" risk; and scores above 20 indicate a "*very high*" risk. Individuals scoring 15 points or higher are recommended to undergo laboratory screening for diabetes and to be included in a prevention program. The FINDRISC categorizes individuals into five risk groups based on the total score (0–26). According to the original FINDRISC model, these categories correspond to an estimated 10-year risk of developing T2D of approximately 1% (very low risk), 4% (low risk), 16% (moderate risk), 33% (high risk), and 50% (very high risk) (18, 20).

Ethical considerations

Prior to the study, permission to use the scales was obtained from the respective authors who developed them. Institutional approval was granted by the Ministry of Environment and Urbanization, Directorate of Support Services, on November 5, 2019 (No: 259105). Ethical approval was obtained from the Eskişehir Osmangazi University Non-Interventional Clinical Research Ethics Committee on December 10, 2019 (No: 37). The study was conducted in accordance with the principles of the Helsinki Declaration, and all participants voluntarily consented to participate.

Statistical analysis

The proportion of missing data in the entire dataset was less than 0.5% (n=9). Prior to analysis, missing values were replaced with the mean substitution to obtain a complete dataset. Skewness and kurtosis coefficients of the scale scores were checked to assess the normality assumption, and all coefficients were found to be between -1.5 and +1.5 (21), indicating that the scale scores were normally distributed. Descriptive statistics were used to characterize the sample, including means and standard deviations (SD) for continuous variables, and frequencies and percentages for categorical variables. Statistical analyses were conducted using Student's t-tests, one-way ANOVA, and Pearson correlation tests.

In this study, multiple linear regression analysis was conducted to examine the associations between selected variables and participants' 10-year risk of T2D. The dependent variable was the FINDRISC score (10-year T2D risk). Categorical variables were transformed into dummy variables prior to analysis. The regression model was constructed using a hierarchical (block-wise) approach. The first block included control variables (age, marital status, perceived general health – very good, perceived general health – good, perceived general health – fair/poor, presence of chronic disease, prescription medication use, visits to the institution's physician, visits to private hospitals, visits to university hospitals, and visits to state hospitals). The second block added the independent variable of the study, the health literacy index. Variables that did not show a statistically significant association with T2D risk in the initial regression step were excluded, and only variables retained in the final model are presented in the results section.

Prior to conducting the regression analysis, assumptions were evaluated. The relationships between the dependent and independent variables were found to be linear, the distribution of residuals met the normality assumption, and variances were homogeneous. The assumption of multicollinearity was tested by examining correlation coefficients, tolerance values, and VIF values. Correlations among independent variables ranged from 0.004 to 0.695, all below the 0.80 threshold. Tolerance values ranged from 0.846 to 0.956, and VIF values ranged from 1.04 to 1.18, indicating no multicollinearity issues (VIF < 5; tolerance > 0.20). To assess the influence of outliers on the model, Cook's distance values were examined, ranging from 0.000 to 0.047. All values being well below 1 indicate that there were no influential outliers significantly affecting the model. Collectively, these findings confirm that the assumptions for regression analysis were met. The statistical significance level was set at $p<0.05$.

Results

Among the participants, 58.7% (n=206) were female, and the mean age was 37.46±10.38 years (min. 20.00; max. 65.00). The mean score on the TSOY-32 scale was 31.92±7.85 (min. 0.00; max. 50.00), with 59% of employees (n=207) having problematic or inadequate HL. The mean index scores of the matrix components of the TSOY-32 scale, along with the frequency distribution of HL categories, are presented in detail in Table 1.

Table 1: The means of the index scores of the matrix components of the TSOY-32 scale and the frequency distribution of HL categories

Components	Mean±SD	Med (Min.–Max.)	Prevalence Values of HL Indices for HL Categories			
			Inadequate n (%)	Problematic n (%)	Sufficient n (%)	Excellent n (%)
General health literacy	31.92±7.85	31.72 (0.00-50.00)	58 (16.5)	149 (42.5)	105 (29.9)	39 (11.1)
Dimensions						
Treatment and services	33.12±7.66	33.33 (0.00-50.00)	41 (11.7)	128 (36.5)	141 (40.2)	41 (11.7)
Disease prevention health promotion	30.68±8.77	30.20 (0.00-50.00)	86 (24.5)	138 (39.3)	86 (24.5)	41 (11.7)
Processes						
Accessing health-related information	33.90±8.51	33.33 (0.00-50.00)	53 (15.1)	83 (23.6)	159 (45.3)	56 (16.0)
Understanding health-related information	33.75±8.20	33.33 (0.00-50.00)	35 (10.0)	127 (36.2)	136 (38.7)	53 (15.1)
Appraising / evaluating health-related information	29.01±9.06	29.16 (0.00-50.00)	130 (37.0)	96 (27.4)	97 (27.6)	28 (8.0)
Applying / using health-related information	30.99±8.66	31.25 (0.00-50.00)	90 (25.6)	110 (31.3)	113 (32.2)	38 (10.8)

SD: Standard deviation, Med: Median, Min: Minimum, Max: Maximum

Participants' mean FINDRISC score was 8.34±4.76 (min. 0.00; max. 25.00). According to the FINDRISC classification, 38.7% of participants (n=136) were in the very low risk category, 37.3% (n=131) in the low risk category, 13.4% (n=47) in the moderate risk category, 9.4% (n=33) in the high risk category, and 1.1% (n=4) in the very high risk category. Based on the original FINDRISC model, these categories correspond to an estimated 10-year risk of developing T2D of approximately 1% for very low risk, 4% for low risk, 16% for moderate risk, 33% for high risk, and 50% for very high risk individuals. Participants who were 45 years or older, married, perceived their general health as fair/poor, had any chronic disease other than diabetes, regularly used prescription medication, or most frequently visited the institution's physician in the past month had a higher 10-year risk of developing diabetes (each $p<0.05$; Table 2).

Table 2: Distribution of the mean scores of the study group from the FINDRISC scale according to some variables that may be associated with diabetes risk levels

Variables	n	FINDRISC	
		Mean±SD	Test Value t / F; p
Health literacy level			
Inadequate	58	9.37±4.65	1.682; 0.170
Problematic/limited	149	8.43±4.73	
Sufficient	105	8.02±4.76	
Excellent	39	7.33±4.85	
Age group			
< 45 age (1)	263	7.43±4.46	24.156; **<0.001**
45-54 age (2)	65	10.47±4.64	
≥ 55 age (3)	23	12.78±4.11	
Intra-group comparison (Scheffe)	(1-2) p<0.001; (1-3) p<0.001		
Gender			
Male	145	8.50±4.38	0.526; 0.599
Female	206	8.23±5.01	
Marital status			
Married	181	9.17±4.73	3.395; **0.001**
Single	170	7.47±4.63	
Educational status			
Associate degree and below	66	8.03±4.58	0.243; 0.785
Bachelor's	194	8.48±4.97	
Postgraduate and above	91	8.27±4.43	
The general perception of health level			
Perfect (1)	21	6.47±3.95	9.355; **<0.001**
Pretty good (2)	116	6.92±4.05	
Good (3)	136	8.81±4.72	
Fair / poor (4)	78	10.15±5.24	

Intra-group comparison (Scheffe)	(1-4) p=0.015 ; (2-3) p=0.015; (2-4) p<0.001		
Presence of any chronic disease other than diabetes			
No	290	8.07±4.66	-2.316; **0.021**
Yes	61	9.62±5.01	
Prescription medication use			
No	261	7.73±4.59	4.170; **<0.001**
Yes	90	10.11±4.82	
In case of any health problem/disease, the first health institution to apply			
Family health center	86	7.37±4.45	
Public hospital	97	8.71±4.84	
University hospital	33	7.27±4.52	1.714; 0.146
Private hospital/examination	86	8.63±4.93	
Occupational physician	49	9.24±4.81	
The most frequently visited healthcare institution in the past month			
Family health center (1)	85	7.54 ± 4.31	
Public hospital (2)	81	7.71 ± 4.73	
University hospital (3)	27	7.25 ± 4.76	3.319; **0.011**
Private hospital/examination (4)	94	8.91 ± 4.93	
Occupational physician (5)	64	9.84 ± 4.75	
Intra-group comparison (Tukey)	(5-1) p=0.027		
Total	351	8.34±4.76	

As participants' HL levels decreased, their risk of developing diabetes in the next ten years increased (p<0.05; Table 3). Similarly, as participants' levels of disease prevention and health promotion, access to treatment and healthcare services, accessing health-related information, understanding health-related information, and applying/using health-related information decreased, the risk of developing diabetes in the next ten years increased (each p<0.05; Table 3).

Table 3: Correlations among FINDRISC, TSOY-32, and TSOY-32's sub-dimensions

Pearson correlation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
[1] FINDRISC (TD2 risk score)	1.000	-	-	-	-	-	-	-
[2] General health literacy	-0.132*	1.000	-	-	-	-	-	-
[3] Treatment and services	-0.117*	0.950**	1.000	-	-	-	-	-
[4] Disease prevention / health promotion	-0.133*	0.960**	0.827**	1.000	-	-	-	-
[5] Accessing health-related information	-0.115*	0.916**	0.899**	0.856**	1.000	-	-	-
[6] Understanding health-related information	-0.138**	0.922**	0.880**	0.884**	0.825**	1.000	-	-
[7] Appraising / evaluating health-related information	-0.080	0.916**	0.853**	0.893**	0.783**	0.793**	1.000	-
[8] Applying / using health-related information	-0.148**	0.895**	0.838**	0.870**	0.748**	0.756**	0.759**	1.000

**p<0.05; **p<0.001*

A multiple linear regression analysis was conducted to examine the independent associations between selected variables and the 10-year risk of T2D among ministry employees. The assumptions of the regression model were met. The Durbin–Watson statistic was 1.93, indicating acceptable independence of residuals. Multicollinearity indicators, as measured by VIF values, ranged from 1.046 to 1.182, indicating no multicollinearity among the variables. The regression model was significant overall, $F(4, 346)=19.67$, $p<0.001$, and explained 18.5% of the variance in FINDRISC scores ($R^2=0.185$).

According to the regression coefficients, age was independently associated with T2D risk (B=0.159, SE=0.023, β=0.347, t=6.98, p<0.001), indicating that FINDRISC scores increased with age.

Perceived general health was also significantly associated with FINDRISC scores. Participants reporting their general health as "very good" had lower T2D risk scores (B=–1.259, SE=0.531, β=–0.124, t=–2.37, p=0.018), whereas those perceiving their health as "fair/poor" had significantly higher FINDRISC scores (B=1.207, SE=0.603, β=0.106, t=2.00, p=0.046). This finding indicates that subjective health perception contributes to notable differences in diabetes risk.

The HL variable, however, did not make a significant contribution to the model (B=–0.027, SE=0.030, β=–0.045, t=–0.90, p=0.370). This result suggests that HL does not have an independent effect on FINDRISC scores when factors such as age and perceived general health are controlled (Table 4).

Table 4: Multiple linear regression analysis of factors associated with FINDRISC scores among ministry employees

Variable	B	SE	Beta	t	p	Correlations		Tolerance	VIF
						Zero-order	Partial		
Model 1. T2D risk (FINDRISC score)									
(Constant)	3.396	1.432		2.372	**0.018**				
Age	0.159	0.023	0.347	6.977	**<0.001**	0.382	0.351	0.952	1.050
General health perception Pretty good	-1.259	0.531	-0.124	-2.372	**0.018**	-0.204	-0.126	0.856	1.168
General health perception Fair / poor	1.207	0.603	0.106	2.001	**0.046**	0.203	0.107	0.846	1.182
Health literacy	-0.027	0.030	-0.045	-0.898	0.370	-0.132	-0.048	0.956	1.046
$R=0.430$; $R^2=0.185$; $F(4.346)=19.668$; $p<0.001$; Durbin Watson=1.930									

B: Standardized coefficient, Beta: Unstandardized coefficient

Discussion

This study examined HL levels, the risk of developing T2D, influencing factors, and the relationship between HL levels and T2D risk in a sample of 351 ministry employees. In this study, the majority of participants were found to have problematic or inadequate health literacy. At the same time, the overall 10-year risk of developing T2D was relatively low. Increasing age and poorer perceived general health were significantly associated with higher FINDRISC scores, whereas health literacy did not show an independent association with diabetes risk in the multivariable model. These findings provide important insights into diabetes risk profiles in a relatively young and educated working population. A study conducted in Egypt found that individuals with low HL had higher diabetes risk scores (12). In our study, although nearly six out of ten participants (59%) were found to have problematic or inadequate HL, their risk of developing T2D was relatively low. Only 10.5% of the sample were at high or very high risk of developing T2D within the next 10 years. This result may be due to the relatively young age of the study group (mean age: 37.46). In a similar study conducted in Türkiye, 21.9% of the sample were found to be at high or very high risk (22). In a study of Australian adults, 89% of the sample were at high risk of developing T2D within the next

five years (23). These findings indicate that age distribution, lifestyle, and obesity prevalence in various populations significantly affect risk levels. Adults at high risk for diabetes often have difficulty accessing information about healthcare, risk factors, and disease prevention (24). Despite the high education level of the sample in our study, the high proportion of participants with problematic or inadequate HL is a notable finding. Although HL is associated with health behaviors (24), individuals with insufficient HL are 2.04 times more likely to have their diabetes risk misestimated (14).

Each one-year delay in the age of diabetes diagnosis is associated with a 4%, 3%, and 5% reduction in the risk of all-cause mortality, macrovascular, and microvascular complications, respectively (25). In our study, participants who were 45 years or older, married, and perceived their general health as fair/poor were more vulnerable to developing T2D within the next 10 years. Higher age was significantly associated with higher FINDRISC scores in our study, indicating an increased diabetes risk with advancing age. This finding is fully consistent with the literature (13, 14). Similarly, in a study by Yıldız et al., married individuals were also found to have a higher risk of diabetes (26). In addition to non-modifiable risk factors such as age, genetic predisposition, and ethnicity, lifestyle factors—including obesity, insufficient physical activity, smoking, and poor sleep patterns—are known to influence the development of T2D (27). Therefore, older and married individuals may be at higher risk of diabetes due to the potential effects of dietary habits and lifestyle on overall health. Another important finding of our study is the effect of perceived general health on the risk of T2D. Participants who reported feeling “very healthy” had lower diabetes risk scores, whereas those who rated their health as “fair/poor” exhibited higher risk. This result supports previous research indicating that subjective health perception is associated with metabolic risk factors (28, 29).

However, in our study, individuals who had at least one chronic disease other than diabetes and those who used prescription medication regularly were found to have a higher likelihood of developing T2D within the next 10 years. Consistent with our findings, O’Meara et al. (2019) reported that individuals expected to develop T2D were more likely to have a mental health condition or ≥1 physical or mental chronic disorder (23). Health service utilization is largely influenced by overall health status and the presence of illness (30). In this context, the findings related to healthcare use are also noteworthy. Participants who most frequently visited their workplace physician in the past month were found to have a higher probability of developing T2D over the next decade. The fact that employees do not need to take leave to access healthcare services and can reach the workplace physician quickly and easily may have contributed to this outcome.

One of the key findings of this study is that the relationship between health literacy and 10-year T2D risk was not significant once control variables were included in the model. The regression analysis revealed that the health literacy index did not exhibit an independent association with the FINDRISC score when factors such as age and perceived general health were considered. This suggests that stronger determinants—such as age and perceived general health—may have attenuated the association between health literacy and the risk of T2D. Nevertheless, the literature indicates that health literacy exerts an indirect influence; its primary impact occurs through the pathway of health literacy → preventive health behaviors → reduced diabetes risk (12). This finding highlights that health literacy is not merely a measure of knowledge but a structural determinant that shapes health behaviors. Therefore, when evaluating the influence of health literacy on T2D risk, it is essential to consider not only the health literacy score itself but also intermediary variables such as lifestyle, behaviors, and motivation. Although health literacy did not demonstrate an independent association with FINDRISC scores in the regression analysis, descriptive analyses showed that decreasing health literacy levels were associated with an increased risk of developing T2D within the next 10 years. This pattern is consistent with previously reported findings in the literature (13, 14, 23, 24, 31). Thus, although HL did not show an independent association with T2D risk in this study, descriptive analyses indicate that declining HL levels are associated with a higher risk of T2D over the next

decade, suggesting that HL may exert its influence indirectly through lifestyle behaviors rather than acting as a direct risk determinant.

Limitations

The findings of this study should be interpreted in light of several limitations. First, as this was a cross-sectional study, causal relationships cannot be established between the variables. Second, the diabetes risk factors assessed in the study were limited to the eight parameters included in the FINDRISC scale. Third, the study was conducted with employees from a single institution, and therefore, the results cannot be generalized to broader populations.

Conclusions

This study examined the HL levels of ministry personnel and their risk of developing T2D within the next 10 years, revealing that approximately 1 in 10 employees is at high risk for T2D. The finding that a substantial proportion of the sample had problematic/inadequate HL highlights the need for structural interventions to support preventive health behaviors in the workforce. Furthermore, descriptive analyses showed that as HL levels decreased, the 10-year risk of developing T2D increased. However, in the regression model, HL was not independently associated with FINDRISC scores when stronger factors such as age and perceived general health were taken into account. This suggests that the influence of HL on T2D risk may not be direct but rather indirect, operating through mediating factors such as diet, physical activity, and other health behaviors. Given that HL is a key component shaping preventive behaviors, the high rate of inadequate HL among employees represents a critical vulnerability in efforts to prevent diabetes. Based on these findings, it is essential to integrate HL components into workplace diabetes prevention programs. Implementation strategies should aim to enhance risk awareness, strengthen the appropriate use of health information, and promote healthy lifestyle behaviors among employees. In addition, regular screenings, educational programs, and tools designed to enhance digital HL may help increase participation in preventive behaviors and reduce the risk of T2D.

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