ANKARA MEDICAL JOURNAL

Research Article

Ankara Med J, 2026;(3):445-466 // 10.5505/amj.2026.53911

DEVELOPMENT AND VALIDATION OF THE DIABETES MELLITUS KNOWLEDGE SCALE: A VALIDITY AND RELIABILITY STUDY

Gülsüm Öztürk Emiral[1], Abide Aksungur[2], Hüsna Sarıca Çevik[3], Hamit Harun Bağcı[4]

[1]Department of Public Health, Ankara Yıldırım Beyazıt University, Ankara, Türkiye
[2]Haymana Vocational School, Ankara University, Ankara, Türkiye
[3]Department of Family Medicine, Ankara University Medical School, Ankara, Türkiye
[4]General Directorate of Public Health, Republic of Türkiye Ministry of Health, Ankara, Türkiye

Correspondence:
Gülsüm Öztürk Emiral (e-mail: dr.gulsum.ozturk@gmail.com)

Submitted: 19.02.2026 // Accepted: 27.07.2026

Ankara Yıldırım Beyazıt University Faculty of Medicine
Department of Family Medicine

ANKARA MEDICAL JOURNAL

Abstract

Objectives: Diabetes Mellitus (DM) is a common non-communicable disease globally. Since children spend a significant amount of time at school, collaboration with school staff is essential for managing both emergencies and long-term complications related to DM. Therefore, assessing the knowledge level of school staff about DM is of great importance. This study aimed to develop a Diabetes Mellitus Knowledge Scale (DM-KS) and to conduct its validity and reliability analysis among teachers.

Materials and Methods: This methodological study was carried out with 379 teachers working under the Altındağ District National Education Directorate during the 2022–2023 academic year. The DM-KS consists of 23 items. Validity was assessed through content validity, item analysis, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and known-groups comparison.

Results: The DM-KS comprises two subscales: "DM General Information and Symptoms" (11 items) and "DM Treatment and Complication Management" (12 items). Item difficulty indices ranged between 0.37 and 0.84, and discrimination coefficients ranged between 0.40 and 0.91. According to EFA, four items were excluded due to overlapping factors, and the factor loadings of the remaining items ranged from 0.39 to 0.76. The explained variances of subscales 1 and 2 were 38.2% and 41.4%, respectively. Cronbach's alpha values were 0.84-0.87. Participants who had received training scored significantly higher in both subscales.

Conclusions: The DM-KS demonstrated acceptable reliability and preliminary evidence of validity for assessing diabetes-related knowledge among teachers. Further validation in independent and diverse samples is warranted.

Keywords: Type 1 diabetes mellitus; diabetes knowledge; diabetes knowledge scale; school health; psychometrics; validity and reliability.

Introduction

Type 1 diabetes is one of the most prevalent long-term diseases of childhood globally. It has major health consequences for individuals and society.[1,2] The IDF Diabetes Atlas (2021) estimates that DM affects 10.5% of adults aged 20–79 years (536.6 million people) and was associated with approximately 6.7 million deaths worldwide in 2021.[3] According to World Health Organization (WHO) data, there are approximately 9 million individuals diagnosed with Type 1 DM, the majority of whom are in high-income countries.[4] In Türkiye, type 1 DM represents a major pediatric burden: approximately 1,700–2,000 children are newly diagnosed each year, and about 30,000 children under 18 live with the condition, most of them school-age.[5,6] Teachers play a critical role in the daily management and safety of children with type 1 diabetes mellitus (T1 DM) in school settings. Inadequate knowledge among school personnel may lead to delayed recognition of hypoglycemia or hyperglycemia, inappropriate emergency responses, and increased risk of acute complications, which can negatively affect both health outcomes and academic performance of students with diabetes. International organizations emphasize that improving diabetes awareness and preparedness in schools is essential for ensuring safe educational environments and preventing diabetes-related emergencies among children. Therefore, assessing teachers' knowledge levels is an important step in planning effective educational interventions and school health policies.[4-6] At school, children need prompt recognition of hypoglycemia and ketoacidosis, meal and activity planning, assistance with glucose monitoring and treatment, and coordinated support from teachers, staff, and families. Therefore, this study aimed to develop and validate a reliable and valid scale to assess teachers' knowledge regarding type 1 diabetes mellitus, including recognition and management of hypoglycemia and hyperglycemia and emergency management in school settings, and to introduce the Diabetes Mellitus Knowledge Scale (DM-KS).

Materials and Methods

This methodological study was conducted with primary, middle, and high school teachers serving in Altındağ District National Education Directorate during the 2022-2023 academic year. This study was carried out within the scope of the project titled: "Evaluation of the Knowledge Level of School Teachers about Diabetes Mellitus", and SBÜ Dr. Abdurrahman Yurtaslan Ankara Onkoloji Research and Hospital Ethics Committee approval (2022-10/172) was received to conduct this study.

Development of Diabetes Mellitus Knowledge Scale

An extensive literature review was conducted to develop the DM-KS. A widely accepted and used DM-KS among teachers could not be found. Therefore, it was decided to develop the DM-KS. While developing the DM-KS, a question pool consisting of 40 items was prepared. In line with expert opinions, the questions were reduced to 27 items and grouped under two subheadings: “Diabetes Mellitus General Information and Symptoms (Subscale 1)” and “Diabetes Mellitus Treatment and Complication Management (Subscale 2)”.

In both subscales of DM-KS, correct answers were evaluated as "2", “I don't know” answers as "1", and incorrect-blank answers were evaluated as "0" points. No correction formula was applied for chance-based success.

Whether DM-KS measures the desired structure was evaluated with content validity. For content validity, the opinions of experts, including public health specialists, family medicine specialists, linguists, internal medicine specialists, and endocrine specialists, were consulted. The questions were examined by experts, and each question was evaluated as 'necessary-adequate', 'necessary but insufficient', and 'unnecessary'. The question root and options were changed. Then, expert opinions were transformed into statistically interpretable quantifiers. The content validity index (CVI) was calculated for each question. In both subgroups, the CVI was above 0.80 (0.87-0.90).[7]

Study group, procedure, and questionnaire form

Our study was conducted with teachers who serve under the Altındağ District National Education Directorate. After obtaining the necessary permissions and informing the school officials, the schools were visited during working hours. The subject and purpose of the study were explained. Those who agreed to participate in the study were asked to complete the questionnaire.

The questionnaire form consists of 2 parts. The first part includes the sociodemographic characteristics of the teachers, and the second part comprises the DM-KS items (27 items).

According to the records of the Ministry of National Education, 4,418 teachers were employed in the Altındağ district at the time of the study. The sample size recommended for developing a new assessment tool is generally 5–10 times the number of scale items.8 Since the initial version of the DM-KS consisted of 27 items, the minimum required sample size was calculated as 270 participants. To ensure representation across educational levels, schools were randomly selected from among primary, secondary, and high schools in the district. Reserve schools were also identified in advance to compensate for potential non-response. Participants were recruited from the selected schools, and all eligible teachers who were present during the data collection period and consented to participate were included in the study. Participation was voluntary, and no incentives were offered. The study was completed with 379 teachers, exceeding the recommended sample size for scale development studies.

Item Analysis

Item difficulty and difficulty index should be calculated when developing assessment tools, such as those measuring ability and success that require performance. The item difficulty index is used to distinguish how difficult or easy an item is, and the item discrimination coefficient is used to distinguish between those who know and those who do not. In our study, item difficulty (Pj) and discrimination coefficients (rjx) were

calculated with the formula P= (H+L/N)*100 and d= (H-L/N/2) formulas (ABBID). Another method used to determine item validity is to compare the item scores of the lower and upper 27% groups. It is based on the assumption that people in the upper 27% group possess the characteristic that the assessment tool aims to measure positively, while those in the lower 27% group exhibit a negative effect. This assumption is also expected to emerge among the items. The scores of the lower- and upper-27 % groups from the evaluation tool are analysed using a significance test to determine the difference between the two averages in independent samples. It is desirable that there is a statistical difference between the two averages. The statistical difference between the lower and upper 27% groups reveals evidence of the validity and distinctiveness of the items in the assessment tool.[7]

Construct Validity

The Kaiser-Meyer-Olkin (KMO) value was examined to decide whether the sample size was suitable for factor analysis. The KMO value ranges from 0 to 1, and it is required to be close to 1 for factor analysis to be effective. In the Exploratory Factor Analysis (EFA) to be performed, a KMO coefficient of 0.60 and above is considered sufficient, but it is desired to be above 0.80. While performing EFA, not all items were analysed at the same time, and it was checked whether they were collected under the determined dimensions.[8]

One method used to determine the construct validity of the developed assessment tool is ""known groups comparison". The intergroup differentiation method assumes that the groups are different in terms of the area to be measured. In our study, teachers who received DM training were expected to achieve higher scores on DM-KS and were compared with those who did not receive training using the Mann-Whitney U test.[7]

One frequently used method in determining construct validity is Confirmatory Factor Analysis (CFA). CFA is a method that allows checking the factor structures revealed in EFA. While the relationships between the items in the evaluation tool are examined with EFA, the relationships between the factors are evaluated with CFA. CFA is a modelling

method used to evaluate the latent structure of a measurement tool and to test the fit between observed variables and latent variables. In this study, the factor structure of the DM-KS was examined using CFA with the LISREL 8.51 software program.

Internal Consistency

The Cronbach's alpha coefficient was calculated to test the reliability of DM-KS and to determine internal consistency.

Scoring DM-KS - Statistical Analysis

Each correct answer given to the DM-KS items was scored as "2", incorrectly marked as "0", and those marked as "I don't know" were scored as "1". As the score obtained from each domain increased, the level of knowledge increased.

Data were evaluated using IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp.). Sociodemographic characteristics were presented with descriptive statistical data (mean, frequency, standard deviation, etc.). The conformity of distribution was evaluated with the Shapiro-Wilk test. Mann-Whitney U, Kruskal-Wallis test, and Spearman correlation analysis were used for statistical analysis.

Ethical Considerations

This study was carried out within the scope of the project titled: 'Evaluation of the Knowledge Level of School Teachers about Diabetes Mellitus', and University of Health Sciences Dr. Abdurrahman Yurtaslan Ankara Oncology Training & Research Hospital Ethics Committee approval (2022-10/172) was received to conduct this study.

Results

DM-KS Validity-Reliability Analysis

The DM-KS item difficulty indexes ranged from 0.37 to 0.84, and the discrimination coefficients ranged from 0.40 to 0.91. According to the item analysis results, no items were extracted from the developed assessment tool.

As a result of the EFA analysis performed to test the construct validity, four items were excluded from the assessment tool because they had a factor load of more than 0.40 in each of the two subscales (overlapping factor) ("item 10: The main effect of insulin hormone is to raise blood sugar.", "item 11: Insulin therapy is in the form of oral tablets.", "item 17: In case of low blood sugar, if the child is conscious, he/she can be sent home.", “Item 21: It is not appropriate for a student with controlled Diabetes Mellitus to attend classes that require exercise, such as physical education.”). The item analysis and EFA results of DM-KS are given in Table 1.

Table 1. Item analysis results and factor loads of DM-KS.

DM-KS items	Pj	rjx	Factor Load
Diabetes Mellitus General Information and Symptoms			
KMO:0.870			
Bartlett's Test of Sphericity:1117.482; 0.000			
Explained Variance:38.20			
1- Diabetes mellitus is a disease with high blood sugar that occurs when the pancreas is unable to produce enough insulin or the body is unable to use insulin effectively.	0.78	0.51	0.61
2- The blood sugar level of an individual without diabetes should not exceed 100 mg/dL in fasting and 140 mg/dL in satiety (2 hours after starting the meal).	0.47	0.70	0.59
3- The two most common types of diabetes mellitus are Type 1 and Type 2 diabetes.	0.53	0.83	0.69
4- The disease, characterised by an increase in blood sugar due to absolute insulin deficiency, is called “Type 1 diabetes mellitus”.	0.37	0.78	0.63
5- Type 1 is the most common type of diabetes mellitus in childhood.	0.40	0.78	0.64
6- Diabetes mellitus is one of the leading chronic diseases worldwide.	0.73	0.53	0.56
7- Findings such as constant thirst/dry mouth, drinking more water than usual, and frequent and copious urination (polyuria) are among the most common findings of diabetes mellitus.	0.84	0.42	0.60
13- A blood sugar level lower than 70 mg/dL is considered hypoglycaemia (low blood sugar).	0.48	0.91	0.70
14- Symptoms such as hand and foot tremors, pale colour, and cold sweating may indicate low blood sugar.	0.75	0.55	0.60
18- Symptoms such as a feeling of thirst, acetone odour in the mouth, and sleepiness may indicate high blood sugar.	0.55	0.80	0.65
22- Diabetes is a lifelong disease.	0.63	0.55	0.50
Diabetes Mellitus Treatment and Complication Management			
KMO:0.893			
Bartlett's Test of Sphericity:1549.145; ≤0.001			
Explained Variance:41.42			

8- Insulin therapy is used in the treatment of type 1 diabetes mellitus.	0.46	0.70	0.51
9- The pancreas is the main organ in which the insulin hormone is secreted.	0.63	0.75	0.65
12- Insulins are drugs subject to the cold chain.	0.39	0.50	0.39
15- In case of low blood sugar, sugar cubes/fruit juice should be given if the child is conscious.	0.65	0.72	0.65
16- In case of low blood sugar, emergency health services should be notified if the child is unconscious.	0.84	0.40	0.56
19- Exercise programs are part of the treatment of diabetes mellitus.	0.60	0.73	0.63
20- In situations that cause anxiety, such as exams, the blood sugar balance may deteriorate.	0.70	0.66	0.68
23- Exercise programs are effective in lowering blood sugar.	0.60	0.80	0.71
24- Failure to control blood sugar creates long-term health problems.	0.83	0.52	0.68
25- If blood sugar is not kept under control in diabetes mellitus, eye damage (blindness, etc.) may occur.	0.65	0.80	0.74
26- If blood sugar is not kept under control in diabetes mellitus, severe kidney disease may develop that may require dialysis and/or kidney transplantation.	0.70	0.70	0.76
27- If blood sugar is not kept under control in diabetes mellitus, diseases such as heart attack and stroke, which may result in death, may develop due to damage to the heart and brain vessels.	0.53	0.81	0.69

Total Explained Variance: 40%, Pj: item difficulty index; rjx: item discrimination coefficients.

In the reliability analysis, the Cronbach's alpha coefficient for subscale-1 was 0.84, and the item-total correlation coefficient ranged between 0.394 and 0.604; the Cronbach's alpha coefficient for subscale-2 was 0.87, and the item-total correlation coefficient ranged between 0.330 and 0.674. Cronbach's alpha coefficient did not increase when any item was removed in both subscales. The reliability analyses of the study are given in Table 2.

Table 2. DM-KS Reliability Analysis Results

DM-KS items	Corrected item-total correlation	Cronbach's alpha if item deleted
Diabetes Mellitus General Information and Symptoms		
***Cronbach's alpha coefficient*: 0.836**		
1- Diabetes mellitus is a disease with high blood sugar that occurs when the pancreas is unable to produce enough insulin or the body is unable to use insulin effectively.	0.507	0.823
2- The blood sugar level of an individual without diabetes should not exceed 100 mg/dL in fasting and 140 mg/dL in satiety (2 hours after starting the meal).	0.481	0.825
3- The two most common types of diabetes mellitus are Type 1 and Type 2 diabetes.	0.592	0.815
4- The disease, characterised by an increase in blood sugar due to absolute insulin deficiency, is called "Type 1 diabetes mellitus".	0.529	0.820
5- Type 1 is the most common type of diabetes mellitus in childhood.	0.540	0.819
6- Diabetes mellitus is one of the leading chronic diseases worldwide.	0.452	0.827
7- Findings such as constant thirst/dry mouth, drinking more water than usual, and frequent and copious urination (polyuria) are among the most common findings of diabetes mellitus.	0.496	0.824
13- A blood sugar level lower than 70 mg/dL is considered hypoglycaemia (low blood sugar).	0.604	0.813
14- Symptoms such as hand and foot tremors, pale colour, and cold sweating may indicate low blood sugar.	0.491	0.824
18- Symptoms such as a feeling of thirst, acetone odour in the mouth, and sleepiness may indicate high blood sugar.	0.541	0.819
22- Diabetes is a lifelong disease.	0.394	0.832
Diabetes Mellitus Treatment and Complication Management		
***Cronbach's alpha coefficient*: 0.865**		
8- Insulin therapy is used in the treatment of type 1 diabetes mellitus.	0.434	0.863
9- The pancreas is the main organ in which the insulin hormone is secreted.	0.555	0.854
12- Insulins are drugs subject to the cold chain.	0.330	0.865

15- In case of low blood sugar, sugar cubes/fruit juice should be given if the child is conscious.	0.566	0.854
16- In case of low blood sugar, emergency health services should be notified if the child is unconscious.	0.470	0.860
19- Exercise programs are part of the treatment of diabetes mellitus.	0.542	0.855
20- In situations that cause anxiety, such as exams, the blood sugar balance may deteriorate.	0.586	0.852
23- Exercise programs are effective in lowering blood sugar.	0.628	0.849
24- Failure to control blood sugar creates long-term health problems.	0.574	0.854
25- If blood sugar is not kept under control in diabetes mellitus, eye damage (blindness, etc.) may occur.	0.642	0.848
26- If blood sugar is not kept under control in diabetes mellitus, severe kidney disease may develop that may require dialysis and/or kidney transplantation.	0.674	0.847
27- If blood sugar is not kept under control in diabetes mellitus, diseases such as heart attack and stroke, which may result in death, may develop due to damage to the heart and brain vessels.	0.599	0.851
Total scale Cronbach's alpha coefficient:0.891		

As another analysis method for DM-KS, the scores of the upper and lower groups (27%) were compared, and it was determined that the scores of the upper group were higher in all subscales of DM-KS (for each subscale, $p<0.05$). The comparison of the item scores of the lower and upper 27% groups is given in Table 3.

Table 3. Comparison of the item scores of the lower and upper 27% groups.

DM-KS		Mean (SD)	Median (Q1-Q3)	Statistical analysis z; p
Subdomain-1	Group of upper 27%	20.6 (1.5)	20.5 (20.0-22.0)	12.398; <0.001
	Group of lower 27%	12.4 (2.5)	12.0 (11.0-14.0)	
Subdomain-2	Group of upper 27%	22.4 (1.7)	23.0 (22.0-24.0)	12.284; <0.001
	Group of lower 27%	13.2 (3.9)	14.0 (12.0-16.0)	

Data are presented as mean (SD) and median (interquartile range). Mann–Whitney U test was used.

For intergroup differentiation, the DM-KS scores of individuals who had received DM training were compared with those who had not received training. As predicted, those who received training beforehand had higher scores in both subscales. Comparisons between groups are given in Table 4.

Table 4. Comparisons between groups.

DM-KS		Mean (SD)	Median (Q1-Q3)	Statistical analysis z; p
Subdomain 1	Those who have not received training on DM	16.5 (3.7)	17.0 (14.0-19.5)	2.521; 0.012
	Those who received training on DM	17.7 (3.6)	19.0 (16.0-20.0)	
Subdomain 2	Those who have not received training on DM	18.2 (4.6)	19.0 (16.0-22.0)	3.189; 0.001
	Those who received training on DM	20.1 (3.7)	21.0 (19.0-23.0)	

Mann–Whitney U test was used. *Q1–Q3: interquartile range (25th–75th percentiles).*

In the CFA conducted for DM-KS, although several goodness-of-fit indices did not meet commonly recommended thresholds, the t-values and factor loadings in the measurement model were within acceptable limits. The measurement model (T values) obtained from the CFA is presented in Figure 1, and the fit indices for this model are listed in Table 5.

Table 5. Fit indices obtained from CFA.

Fit indices	**Fit values of the measurement model obtained for the DM-KS**
χ^2 /df	6.50
RMSEA	0.12
SRMR	0.08

CFI	0.89
GFI	0.74
AGFI	0.69

df: degrees of freedom; RMSEA: root mean square error of approximation; SRMR: standardized root mean square residual; CFI: comparative fit index; GFI: goodness of fit index; AGFI: adjusted goodness of fit index.

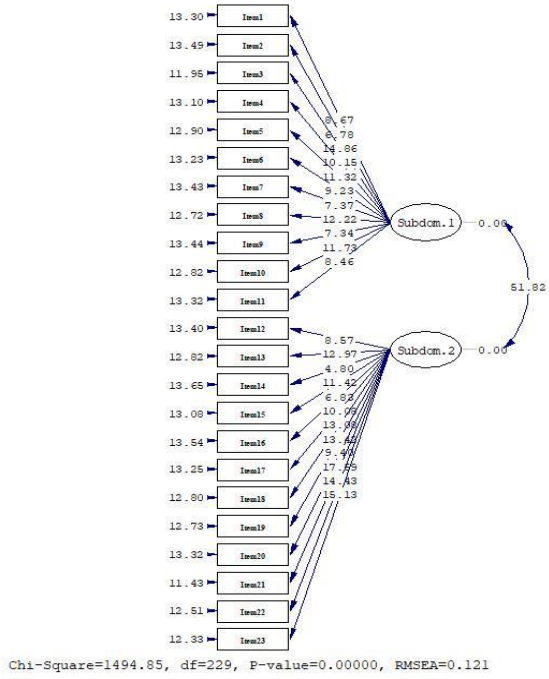


Figure 1. The measurement model obtained from the CFA

Characteristics of Participants

281 (74.1%) of the participants in the study were female. Their ages ranged from 22 to 62 years, with a mean (SD) of 39.7 (9.3) years. DM-KS scores were not significantly associated with most sociodemographic characteristics ($p > 0.05$). However, teachers with a chronic disease demonstrated significantly higher DM-KS scores compared with those without a chronic disease ($p = 0.008$) (Table 6).

Table 6. Comparison of sociodemographic characteristics of participants and DM-KS.

		n (%)	DM-KS	Statistical Analysis
			Median (Q1-Q3)	Kw;z: p
Age group	<35	130 (34.3)	16.0 (12.0-20.0)	5.229; 0.073
	35-44	126 (33.2)	17.0 (10.0-22.0)	
	≥45	123 (32.5)	19.0 (13.0-22.0)	
Sex	Female	281 (74.1)	17.0 (13.0-22.0)	1.677; 0.094
	Male	98 (25.9)	16.0 (10.0-21.0)	
School type	Primary school	97 (25.6)	17.0 (13.0-21.0)	2.263; 0.323
	Middle school	126 (33.2)	16.5 (11.0-21.0)	
	High school	156 (41.2)	17.5 (11.5-22.0)	
Working position	Director/Manager	27 (7.1)	20.0 (12.0-23.0)	1.114; 0.265
	Teacher	352 (92.9)	17.0 (12.0-21.0)	
Perceived income level	Poor	45 (11.9)	16.0 (10.0-21.0)	2.767; 0.251
	Middle	250 (66.0)	17.0 (12.0-21.0)	
	Good	84 (22.2)	18.0 (13.5-22.0)	
Having a child	Yes	271 (71.5)	17.0 (11.0-21.0)	0.532; 0.594
	No	108 (28.5)	17.0 (13.0-22.0)	
Having a chronic disease	Yes	77 (20.3)	19.0 (14.0-23.0)	***2.637; 0.008***
	No	302 (79.7)	16.5 (11.0-21.0)	

Kruskal Wallis/ *Mann–Whitney U test was used.* Q1–Q3: interquartile range (25th–75th percentiles).

Discussion

DM has become a major public health problem in Türkiye. According to the IDF, approximately 9 million individuals were living with DM in Türkiye in 2021, and an estimated 30,000 children under 18 years have type 1 DM.[5,6] Because children spend a substantial proportion of their time at school, early recognition of DM symptoms, awareness of emergency signs in children with DM, and prevention of acute and long-term complications are critically dependent on school personnel.[9] Consequently, teachers must possess adequate DM knowledge, and our study therefore aimed to develop a Diabetes Mellitus Knowledge Scale (DM-KS) and to conduct its validity and reliability analysis among teachers.

In developing a new assessment tool, items should not be excessively easy or difficult and should discriminate between knowledgeable and non-knowledgeable individuals. For this purpose, an item discrimination coefficient of ≥0.20 is generally recommended.[10] In our study, DM-KS item difficulty indices ranged from 0.37 to 0.84, and discrimination coefficients from 0.40 to 0.91, indicating satisfactory psychometric performance. Item discrimination was further confirmed by comparing the lower and upper 27% groups, and all items of the DM-KS were discriminative. In the Diabetes Knowledge Questionnaire validation study by Hsieh et al., item difficulties ranged from 0.285 to 0.993 and discriminations from 0.199 to 0.578, while Garcia et al. reported difficulty indices between 0.14 and 0.96 and discrimination values between 0.27 and 0.37.[11,12] Overall, the item characteristics of DM-KS were comparable or superior to those reported in previous instruments.

Exploratory factor analysis (EFA) was used to examine the construct validity of DM-KS. Bartlett's test of sphericity indicated that the item correlation matrix was suitable for factor analysis, and the Kaiser–Meyer–Olkin measure showed adequate sampling. In line with recommendations in the social sciences, where an explained variance of 40–60% is considered acceptable,[7] the two-factor structure of DM-KS accounted for 40% of the total variance and was considered satisfactory.

Factor loadings reflect the weights of items on their respective latent constructs and are typically expected to be ≥0.30.[7] In DM-KS, all item loadings exceeded 0.30, indicating that each item contributed adequately to its factor. Consistent with our approach, Hsieh et al. removed items with factor loadings <0.30 in their Taiwanese validation study, and Yavuz and Erol excluded items with loadings <0.20, with the lowest retained loading being 0.30.[12,13]

Construct validity was also supported by known-groups (intergroup) differentiation. As hypothesised, teachers who had previously received DM training achieved significantly higher DM-KS scores than those without such training, demonstrating the scale's ability to discriminate between groups with differing knowledge levels. Similarly, Bukhsh et al. reported higher diabetes knowledge scores among individuals with good glycaemic control compared with those with poor control, and Al-Qazaz et al. found parallel associations between knowledge and self-management indicators.[14,15] These convergent findings further support the construct validity of DM-KS.

Internal consistency is a key component of reliability. A Cronbach's alpha coefficient of ≥0.70 is generally regarded as acceptable.[7] In our study, Cronbach's alpha values for the overall DM-KS and for both subscales exceeded 0.80, indicating high internal consistency. Previous diabetes knowledge scales developed or adapted in different languages have reported alpha values of ≥0.70, and our results therefore fall within, or above, the range reported in the literature.[11,16] Differences in scoring formats, sample characteristics, and scale length across studies may partly account for variability in alpha values, yet the overall pattern consistently supports adequate reliability.

Confirmatory factor analysis (CFA) was conducted to test the two-factor structure identified in EFA. CFA evaluates the fit between observed variables and latent constructs by multiple fit indices; however, there is no universal consensus on optimal cut-off values, and indices are influenced by factors such as sample size, model complexity, and data distribution[17]. In our analysis, all item t-values exceeded 1.96 and all item–factor correlations were statistically significant, supporting the specified factor structure.

Although some goodness-of-fit indices did not meet commonly recommended thresholds, the findings provided preliminary support for the proposed two-factor structure when considered together with the factor loadings, theoretical coherence, and other psychometric findings. It is well recognized that model fit indices may be affected by sample characteristics, model complexity, and item distributions, and strict adherence to cut-off values alone may lead to incorrect conclusions regarding model adequacy. Previous methodological literature emphasizes that acceptable model fit should be interpreted holistically by considering theoretical justification, factor loadings, and reliability estimates rather than relying solely on numerical thresholds. Therefore, while the findings support the proposed factor structure, the factorial validity evidence should be interpreted with caution and considered preliminary. Furthermore, because both EFA and CFA were conducted using the same sample, future studies involving independent samples are needed to provide additional evidence regarding the stability and generalizability of the factor structure.[18-20]

After finalising DM-KS, we examined its ability to distinguish subgroups defined by relevant teacher characteristics. Teachers with chronic diseases had higher DM-KS scores than those without chronic conditions. Comparable observations have been reported in studies from rural China, where adults with chronic diseases or a positive family history showed more extensive knowledge of chronic conditions, and among older individuals with a family history of chronic disease.[21,22] These findings likely reflect increased health-seeking behaviour and more frequent contact with healthcare professionals, which in turn may enhance disease-related knowledge.

Strengths and Limitations

This study contributes to the existing literature by providing a psychometrically tested instrument developed and evaluated among teachers to assess knowledge regarding type 1 diabetes mellitus in school settings. Although several diabetes knowledge scales exist in the literature, most of them were developed for patients or healthcare professionals and may not adequately capture the educational and practical needs of school personnel. The

present scale addresses this gap by focusing on teachers, who play a critical role in recognizing symptoms, preventing complications, and responding to diabetes-related emergencies during school hours. In addition, the inclusion of both exploratory and confirmatory factor analyses provides preliminary evidence regarding the structural validity of the instrument. Therefore, *DM-KS* may serve as a useful tool for assessing educational needs, planning training programs, and evaluating interventions aimed at improving diabetes management and safety in school environments.

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in a single district, and participants were recruited using a convenience sampling approach, although schools were randomly selected, which may limit the generalizability of the results to other regions or populations. Second, data were collected using self-report questionnaires, which may introduce response bias, including social desirability bias, and may not fully reflect participants' actual knowledge levels. Third, although both exploratory and confirmatory factor analysis were performed, the CFA was conducted on the same sample rather than an independent validation sample, which may limit the strength of the structural validation. In addition, some CFA model fit indices did not fully meet the recommended thresholds, and therefore the factorial validity findings should be interpreted with caution. Additionally, test–retest reliability was not assessed due to time constraints, and therefore the temporal stability of the scale could not be evaluated. Future studies including larger and more diverse samples, independent validation groups, and longitudinal reliability assessments are recommended to further strengthen the psychometric properties of the scale.

In conclusion, the Diabetes Mellitus Knowledge Scale (DM-KS) demonstrated acceptable reliability and preliminary evidence of validity for assessing teachers' knowledge regarding type 1 diabetes mellitus and its management in school settings. The findings suggest that the scale has promising psychometric properties and may serve as a practical tool for identifying knowledge gaps among teachers and guiding educational

interventions. Further validation in independent samples is warranted to confirm the stability and generalizability of its factor structure.

The DM-KS may also be useful for evaluating the effectiveness of training programs and supporting school health policies aimed at enhancing preparedness for diabetes care in educational environments. Future research involving larger and more diverse populations, independent validation samples, and longitudinal studies assessing temporal stability would provide additional evidence regarding the applicability and psychometric performance of the scale across different settings.

Ethical Considerations: This study was carried out within the scope of the project titled: "Evaluation of the Knowledge Level of School Teachers about Diabetes Mellitus", and SBÜ Dr. Abdurrahman Yurtaslan Ankara Onkoloji Research and Hospital Ethics Committee approval (2022-10/172) was received to conduct this study.

Conflict of Interest: The authors declare no conflict of interest.

References

1. Alberti KGMM, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus. Diabet Med. 1998;15(7):539-553. doi:10.1002/(SICI)1096-9136(199807)15:7<539::AID-DIA668>3.0.CO;2-S.
2. Turkish Society of Endocrinology and Metabolism. Diabetes mellitus ve komplikasyonlarının tanı, tedavi ve izlem kılavuzu. 15th ed. Ankara: Bayt Yayınları; 2022.
3. International Diabetes Federation. IDF Diabetes Atlas 2021 [Internet]. Brussels: International Diabetes Federation; 2021 [cited 2025 Aug 7]. Available from: https://diabetesatlas.org/atlas/tenth-edition/
4. World Health Organization. Diabetes [Internet]. Geneva: World Health Organization; 2023 [cited 2025 Aug 7]. Available from: https://www.who.int/news-room/fact-sheets/detail/diabetes
5. Roglic G. WHO global report on diabetes: A summary. Int J Noncommun Dis. 2016;1(1):3-8. doi:10.4103/2468-8827.184853
6. Hatun S. Okulda diyabet programı eğitim platformu [Internet]. 2022 [cited 2025 Aug 7]. Available from: https://okuldadiyabet.meb.gov.tr/okulda-diyabet-programi-hakkinda
7. Alpar R. Spor, sağlık ve eğitim bilimlerinden örneklerle uygulamalı istatistik ve geçerlik güvenirlik. 7th ed. Ankara: Detay Yayıncılık; 2022.
8. Tavşancıl E. Tutumların ölçülmesi ve SPSS ile veri analizi. 6th ed. Ankara: Nobel Akademik Yayıncılık; 2010.
9. Republic of Turkey Ministry of Health, Public Health Institution of Turkey. Türkiye Diyabet Programı 2015-2020. Ankara: Kuban Yayıncılık; 2014.
10. Baykul Y. Eğitimde ve psikolojide ölçme: Klasik test teorisi ve uygulaması. 7th ed. Ankara: Pegem Akademi; 2024.
11. Garcia AA, Villagomez ET, Brown SA, Kouzekanani K, Hanis CL. The Starr County diabetes education study: Development of the Spanish-language diabetes

knowledge questionnaire. Diabetes Care. 2001;24(1):16-21. doi:10.2337/diacare.24.1.16

12. Hsieh MH, Chen YC, Ho CH, Lin CY. Validation of diabetes knowledge questionnaire (DKQ) in the Taiwanese population: Concurrent validity with diabetes-specific quality of life questionnaire module. Diabetes Metab Syndr Obes. 2022;15:2391-2403. doi:10.2147/DMSO.S369552
13. Yavuz K, Erol S. Developing a diabetes knowledge scale for adults and its psychometric properties. Clin Exp Health Sci. 2022;12(3):711-718. doi:10.33808/clinexphealthsci.1014888
14. Bukhsh A, Lee SWH, Pusparajah P, Khan AH, Khan TM. Psychometric properties of the Urdu version of diabetes knowledge questionnaire. Front Public Health. 2017;5:139. doi:10.3389/fpubh.2017.00139
15. Al-Qazaz HK, Hassali MA, Shafie AA, Sulaiman S, Sundram S. The 14-item Michigan diabetes knowledge test: Translation and validation study of the Malaysian version. Pract Diabetes Int. 2010;27(6):238-241. doi:10.1002/pdi.1495
16. Cacic M, Kruljac I, Mirosevic G, Vrkljan M. Validation of diabetes knowledge questionnaire in Croatian with assessment of diabetes knowledge and quality of life in patients with type 2 diabetes mellitus. Clin Diabetol. 2020;9(6):387-393. doi:10.5603/DK.2020.0054.
17. Schreiber JB, Nora A, Stage FK, Barlow EA, King J. Reporting structural equation modeling and confirmatory factor analysis results: A review. J Educ Res. 2006;99(6):323-338. doi:10.3200/JOER.99.6.323-338
18. Brown TA. Confirmatory factor analysis for applied research. 2nd ed. New York: Guilford Press; 2015.
19. Brown TA, Moore M. Confirmatory factor analysis. In: Hoyle RH, editor. Handbook of structural equation modeling. New York: Guilford Press; 2012. p. 361-379.
20. Browne MW, Cudeck R. Alternative ways of assessing model fit. Sociol Methods Res. 1992;21(2):230-258. doi:10.1177/0049124192021002005
21. Tian M, Chen Y, Zhao R, Chen L, Chen X, Feng D, et al. Chronic disease knowledge and its determinants among chronically ill adults in rural areas of Shanxi Province

in China: A cross-sectional study. BMC Public Health. 2011;11:948. doi:10.1186/1471-2458-11-948.

22. Song Y, Ma W, Yi X, Wang S, Sun X, Tian J, et al. Chronic diseases knowledge and related factors among the elderly in Jinan, China. PLoS One. 2013;8(6). doi:10.1371/journal.pone.0068599