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# Knowledge profiles about type 1 and type 2 diabetes mellitus among health professionals and medical students

# Perfis de conhecimento sobre diabetes mellitus tipos 1 e 2 entre profissionais de saúde e estudantes de medicina

# Perfiles de conocimiento sobre la diabetes mellitus tipos 1 y 2 entre profesionales de la salud y estudiantes de medicina

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**ABSTRACT**

**Objective**: To compare knowledge profiles regarding types 1 and 2 diabetes mellitus among healthcare professionals and students. **Methods**: Analytical cross-sectional study with an exploratory approach and chain sampling. The Diabetes Basic Knowledge Test was used as the instrument. Analyses were conducted in RStudio and included descriptive statistics, Student's t-test, chi-square test, Fisher's exact test, Cohen's d, hierarchical cluster analysis, and principal component analysis (PCA). **Results:** A total of 105 individuals participated (63 professionals and 42 students), mostly women, of mixed race, and nurses. Medical students showed higher average scores. Questions related to prevention and treatment had the highest accuracy rates; the most frequent errors occurred in insulin preparation, the Somogyi effect, and storage. The cluster analysis identified three knowledge profiles (low, intermediate, and high), which were supported by the distribution of participants in the principal component analysis factor space. The first two principal components explained 17.18% of the total variance. Internal consistency was moderate (alpha = 0.67). **Conclusion:** Knowledge gaps in diabetes management were identified, even among more experienced professionals, highlighting the need for ongoing training and updating of educational tools according to current guidelines.

**DESCRIPTORS:**
Diabetes Mellitus; Knowledge; Health Professionals; Medical Students.

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**RESUMO**

**Objetivo**: Comparar perfis de conhecimento sobre diabetes mellitus tipos 1 e 2 entre profissionais e estudantes da área da saúde. **Metódos:** Estudo transversal analítico com abordagem exploratória e amostragem em cadeia. Utilizou-se o instrumento *Diabetes Basic Knowledge Test*. As análises foram realizadas no RStudio, incluindo estatísticas descritivas, teste t de Student, qui-quadrado, exato de Fisher, d de Cohen, análise de cluster hierárquica e análise de componentes principais. **Resultados:** Participaram 105 indivíduos (63 profissionais e 42 estudantes), majoritariamente mulheres, pardas e enfermeiras. Estudantes de medicina apresentaram as maiores médias de acertos. As questões sobre prevenção e tratamento tiveram maior taxa de acertos; os maiores erros ocorreram em preparo de insulinas, efeito Somogyi e armazenamento. A análise de cluster revelou três perfis de conhecimento (inicial, intermediário e elevado), corroborado pela dispersão no espaço fatorial da análise de componentes principais, que explicou 17,18% da variância total. A consistência interna foi moderada (alfa = 0,67). **Conclusão:** Identificaram-se lacunas no conhecimento sobre o manejo do diabetes, inclusive entre profissionais mais experientes, evidenciando a necessidade de capacitação contínua e atualização dos instrumentos educativos conforme diretrizes atuais.

**DESCRITORES:**
Diabetes Mellitus; Conhecimento; Profissionais de Saúde; Estudantes de Medicina.

**RESUMEN:**

**Objetivo:** Comparar los perfiles de conocimiento sobre la diabetes mellitus tipos 1 y 2 entre profesionales y estudiantes del área de la salud. **Métodos:** Estudio transversal analítico con enfoque exploratorio y muestreo en cadena. Se utilizó el instrumento *Diabetes Basic Knowledge Test*. Los análisis se realizaron en RStudio, incluyendo estadísticas descriptivas, prueba t de Student, chi-cuadrado, prueba exacta de Fisher, d de Cohen, análisis de clúster jerárquico y análisis de componentes principales (PCA). **Resultados:** Participaron 105 individuos (63 profesionales y 42 estudiantes), en su mayoría mujeres, de raza mixta y enfermeras. Los estudiantes de medicina obtuvieron mayores promedios de aciertos. Las preguntas sobre prevención y tratamiento tuvieron las tasas más altas de aciertos; los errores más frecuentes se observaron en la preparación de insulinas, el efecto Somogyi y el almacenamiento. El análisis de conglomerados identificó tres perfiles de conocimiento (inicial, intermedio y elevado), respaldados por la distribución de los participantes en el espacio factorial del análisis de componentes principales. Los dos primeros componentes principales explicaron el 17,18% de la varianza total. La consistencia interna fue moderada (alfa = 0,67). **Conclusión**: Se identificaron brechas en el conocimiento sobre el manejo de la diabetes, incluso entre profesionales con más experiencia, lo que evidencia la necesidad de una capacitación continua y la actualización de los instrumentos educativos conforme a las directrices actuales.

**DESCRIPTORES:**
Diabetes Mellitus; Conocimientos; Profesionales Sanitarios; Estudiantes de Medicina.

## INTRODUCTION

Diabetes Mellitus (DM) is a chronic condition with a significant impact on global public health[1] that requires daily care, self-management, and ongoing education to prevent acute and chronic complications[2]. Between 1990 and 2019, there was a 24.4% global increase in Disability-Adjusted Life Years (DALY) rates due to diabetes[3]. The national scenario is equally concerning, with DM ranking as the third leading cause of death (49.74 per 100,000 inhabitants) and the seventh leading cause of DALYs[4].

Given this reality, the importance of implementing preventive measures, such as diabetes education for affected individuals and their families, as well as for current and future healthcare professionals, cannot be overstated[5-6]. Although DM treatment has seen significant advances in recent years, with the emergence of more effective, technology-driven therapies, including improvements in insulin administration and glycemic monitoring, these advances translate into better clinical outcomes only if professionals are adequately trained to manage and guide their patients[7-8].

## OBJECTIVE

To compare knowledge profiles about types 1 and 2 diabetes mellitus among healthcare professionals and students.

## METHODOLOGY

### Study design, period and site

This is an exploratory, analytical cross-sectional study. Data were collected between June and July 2023 and between February and April 2024 (the periods during which the undergraduate research project that gave rise to this study was conducted). The study was carried out in the auditorium of the Health Sciences Training Center at the Federal University of Southern Bahia (UFSB), in the municipality of Teixeira de Freitas, Bahia.

### Sample; inclusion and exclusion criteria

Healthcare professionals (doctors, nurses, social workers, pharmacists, nutritionists, physical educators, nursing technicians, and pharmacy technicians) working in health services within the Teixeira de Freitas state health region, as well as medical students from UFSB, were invited to participate in the study.

Sampling was conducted using chain sampling—also known as network or snowball sampling[9], by promoting the research on Instagram® and WhatsApp® with recruitment links: one aimed at professionals and the other at students. This is a type of non-probability sampling and a variant of convenience sampling. To carry it out, we asked the initial sample members to refer other participants who met the eligibility criteria[9]. It is worth noting that this type of sampling is an effective strategy for the rapid recruitment of participants in educational programs[10].

The inclusion criteria were: (a) being a healthcare professional with active registration with the regional professional council in one of the municipalities belonging to the Teixeira de Freitas state health region (Bahia) and (b) being 18 years of age or older; and for the UFSB student group: (a) being a medical student aged 18 or older and (b) having active enrollment status.

Health professionals who had been away from clinical care or management roles in public or private health services for more than a year, as well as those who reported participating in another diabetes education program during recruitment (n = 4), were excluded from the data analysis. Also excluded were medical students who had not yet entered the clinical rotation or internship phase of their program and who reported participating in another diabetes education program during recruitment (n = 1).

The sample composition and the comparative analysis between health professionals and medical students are grounded in the principles of education-service integration and interprofessionalism. This approach is theoretically justified by the need to assess whether the students' up-to-date academic training, based on the latest clinical guidelines incorporated into undergraduate curricula, is comparable to the knowledge retained and applied in daily clinical practice by professionals. Such a comparison is particularly relevant given that, within Primary Health Care, the management of diabetes mellitus is a shared responsibility between doctors and nurses, requiring cross-cutting competencies to ensure patient safety and effective self-care.

**Study protocol**

Following study enrollment and informed consent, participants were notified of the date and time the refresher course would begin. Thus, prior to the first class, the data collection instrument known as the Diabetes Basic Knowledge Test (DBKt) was administered, with a one-hour time limit for completion[11].

The DBKt was originally developed and validated by other researchers in the late 1980s, cross-culturally adapted for Brazil in 2015, and originally consists of 41 objective questions[12-14]. However, to assess participants' prior knowledge, six questions (Q) were excluded: Q11: “When should a patient with well-controlled diabetes check for the presence of ketonemia/ketonuria?”; Q12: “What should a person with diabetes do if they have blood glucose levels above 250 mg/dL for two consecutive days and also test positive for ketonemia/ketonuria?”; Q18: “Which option is not a reported side effect of oral hypoglycemic agents?”; Q35: “A person with type 1 diabetes dislikes one of the foods on their meal tray. What is the best advice the nurse can give?”; Q36: “Which of these is the primary goal when developing a diet for a person with type 2 diabetes?”; and Q39: “A person with diabetes refused an afternoon snack consisting of fruit juice and half a sandwich. This should be replaced by”.

These questions were excluded because their answers—according to the cross-culturally adapted instrument—were outdated regarding the 2023 and 2024 Brazilian guidelines on diabetes[15-21]. The questionnaire administered in the present study comprised 35 questions.

Prior knowledge regarding diabetes was assessed based on the mean number of correct answers on the DBKt as a whole and the proportion of correct answers for each question among the professionals

and students. The variables in this study are sociodemographic, professional, and related to performance on diabetes knowledge. Sociodemographic variables include sex (categories: female, male), age (in full years), and ethnicity/skin color (categories: white, Black/mixed-race/Indigenous). Professional variables encompass “healthcare professional” (yes, no), “time since graduation” (in full years), and “postgraduate education” (yes, no). Participant performance was assessed using the outcome variable “number of correct answers,” representing the total number of correct responses on the DBKt. Specific knowledge was measured via 35 pairs of objective questions, identified as Q1 through Q35, with responses categorized as A (correct) or E (incorrect). These variables were subsequently converted into a binary scale for statistical analysis.

**Statistical and results analysis**

Data relating to sociodemographic characteristics and participants' correct answers to the DBKt were entered into a Microsoft Excel 365 software spreadsheet and this was then sent to the RStudio programming language version 4.4.3. In it, qualitative variables were converted into factors and quantitative variables into numerical variables to ensure compatibility with the statistical methods used. The absolute and relative frequencies were calculated for the categorical variables and median and interquartile range for the numerical variables, as these did not present a normal distribution and have distant minimum and maximum values.

The outcome variable “number of correct answers” has a normal distribution, verified by the Kolmogorov-Smirnov test ($p > 0.05$). Therefore, Student's t test for independent samples and Cohen's d test were used to determine the effect size, as it compares the two means and quantifies the difference between the results of the two groups in relation to standard deviations[21].

The absolute and relative frequency of correct answers and errors/I don't know, per question, among health professionals and medical students was calculated and the association between the two groups, for each question, was verified by the chi-square test with Yates' correction and Fisher's exact test.

Comparison between groups was carried out by question and total score. For each individual question, Pearson's chi-square test was applied; in cases where the expected value was less than five, Fisher's exact test was used. For the total score, the Student's t test was used for independent samples with Welch's correction, assuming unequal variances between groups. The magnitude of the differences was estimated using Cohen's d effect measure, accompanied by a 95% confidence interval.

After coding the answers to the 35 knowledge questions (binary values: 1 = correct answer; 0 = incorrect/don't know), a hierarchical cluster analysis was conducted to identify distinct knowledge profiles among the participants.

The use of hierarchical cluster analysis is justified by the possibility of identifying distinct profiles of knowledge, overcoming the limitation of analyzes based exclusively on the global score and highlighting the multidimensional nature of knowledge about diabetes. This approach contributes to the diagnosis of skills and the planning of continuing education strategies aimed at the specific needs of each group[22].

To identify the profiles, Euclidean distance was used as a measure of dissimilarity between individuals, alongside the complete linkage method. The definition of three groups (k=3) was based on the best visual separation of the clusters and consistency with the empirical distribution of observed scores, allowing for the distinction between initial, intermediate, and high profiles. Cluster interpretation was further facilitated by the prior removal of six DBKt questions that were outdated relative to the 2023 and 2024 guidelines of the Brazilian Diabetes Society[15-20]. This adjustment reduced the influence of items incompatible with current recommendations on participant classification, prioritizing the assessment of clinically up-to-date knowledge.

Each participant was then classified into one of three knowledge profiles, named according to the mean total number of correct answers (from lowest to highest performance): Initial Profile – lowest mean of correct answers; Intermediate Profile – median performance; High Profile – highest mean of correct answers.

Subsequently, to examine the structure underlying the responses, a principal component analysis (PCA) was performed using unsupervised rotation and data standardization. The variance explained by the components, the variable (question) weights for the first two components, and the internal consistency coefficient (Cronbach's alpha) for items with the highest factor loadings were evaluated. Visualizations were generated using scatter plots of individuals and biplots of variables and clusters, featuring 95% confidence ellipses.

The international Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline was used to guide the writing and presentation of this study[23].

### Ethical aspects

This study was approved by the Research Ethics Committee of the Federal University of Southern Bahia (CAAE 68863823.9.0000.8467, opinion 6.067.849).

## RESULTS

The final sample consisted of 105 individuals, comprising 63 healthcare professionals (60%) and 42 medical students (40%). Regarding sociodemographic characteristics, 85.7% of the healthcare professionals and 78.6% of the medical students were female. The median age was 38 ± 11.5 years for healthcare professionals and 27 ± 4.0 years for medical students. There was a higher participation of nurses (79.4%) and professionals with a specialization (60.7%) (Table 1).

**Table 1.** Sociodemographic characteristics of the study participants. Teixeira de Freitas – Bahia, Brazil, 2024.

| Sociodemorgaphic characteristics | Health professionals [n = 63 (100%)] | Medical students [n = 42(100%)] |
|---|---|---|
| Sex [n (%)] | | |
| Female | 54 (85.7) | 33 (78.6) |
| Male | 9 (14.3) | 9 (21.4) |
| Age [median(IQR*)] | 38 (11.5) | 27 (4.0) |
| Ethnicity/Skin color [n(%)] | | |
| White | 18 (28.6) | 13 (31) |
| Black | 9 (14.3) | 4 (9.5) |
| Brown | 36 (57.1) | 21 (50) |
| Indigenous | | 1 (2.4) |
| Did not answer | | 3 (7.1) |
| Profession [n(%)] | | |
| Doctor | 2 (3.2) | |
| Nurse | 50 (79.4) | |
| Pharmacist | 5 (7.9) | |
| Social worker | 1 (1.6) | |
| Nutritionist | 1 (1.6) | |
| Physical educator | 1 (1.6) | |
| Nursing technician | 2 (3.2) | |
| Pharmacy technician | 1 (1.6) | |
| Academical degree [n(%)] | | |
| Technician | 3 (5.4) | |
| Graduation | 18 (32.1) | |
| Specialization | 34 (60.7) | |
| MSc | 1 (1.8) | |
| Years of profession exercise [median(IQR)] | 12 (10.3) | |

*IQR - Interquartile Range.

Although the mean (±SD) and proportion of correct answers among students (22.8 ± 3.9; 65.1%) were numerically higher than those of healthcare professionals (21.9 ± 3.7; 62.5%) on the 35 DBKt questions, this difference was not significant ($p = 0.24$) and showed a small effect size (Cohen's $d = 0.23$).

A statistical difference was observed when comparing the frequencies of incorrect/"don't know" responses and correct answers between healthcare professionals and medical students for the following questions (Q): Q1 (etiological characteristic of type 1 diabetes); Q3 (etiological characteristic of type 2 diabetes); Q14 (procedure following needle contamination during insulin preparation); Q22 (effect of illness on insulin requirements for a person with diabetes); Q24 (long-term complications associated with diabetes); Q28 (procedure for a leg abrasion in a person with diabetes); and Q31 (most appropriate initial action to treat a person with type 1 diabetes experiencing hypoglycemia). Table 2 shows the proportions of correct answers and incorrect/"don't know" responses for each DBKt question.

Considering the total sample, the questions with the highest proportion of correct answers concerned foot care (98.1%); treatment of type 2 diabetes mellitus (95.2%); the effect of insulin on blood glucose (95.2%); the test determining average blood glucose (93.3%); long-term complications of diabetes (92.4%); symptoms associated with diabetic ketoacidosis (89.5%); action taken after contaminating an insulin injection needle (86.7%); causes of hypoglycemia in patients using insulin or oral hypoglycemic agents (86.7%); the effect of physical and emotional stress on diabetes control (84.8%); and normal fasting blood glucose levels (83.8%). effect of physical exercise on blood glucose levels when below 250 mg/dL (83.8%); assumptions regarding blood glucose in an unconscious diabetic patient and initial actions (82.9%); peak action of regular insulin (81.0%); etiology of type 2 diabetes (80.0%); and causes of diabetic ketoacidosis (78.1%).

The questions with the highest proportion of incorrect answers or "don't know" responses concerned mixing two insulins in the same syringe (89.5%); characteristics of the Somogyi effect (85.7%); symptoms of hypoglycemia (79.0%); storage of insulin currently in use (75.2%); initial action to treat hypoglycemia (74.3%); insulin administration regimen for a patient undergoing surgery (67.6%); etiology of type 1 diabetes (67.6%); physiological actions of insulin (62.9%); and the effect of illness on the insulin requirements of a person with diabetes (60.0%).

**Table 2.** Comparison of the proportion of errors/"don't know" responses and correct answers on the Diabetes Basic Knowledge Test (DBKt) between healthcare professionals and medical students. Teixeira de Freitas – Bahia, Brazil, 2024.

| Questions | Answer | Health professionals [n (%)] | Medical students [n (%)] | *p*-value |
|---|---|---|---|---|
| Q1: Etiological characteristic of type 1 diabetes | Incorrect/ Don't know | 49 (46.7) | 22 (21.0) | 0.012* |
| | Correct | 14 (13.3) | 20 (19.0) | |
| Q2: Treatment of type 1 diabetes | Incorrect/ Don't know | 19 (18.1) | 7(6.7) | 0.181* |
| | Correct | 44 (41.9) | 35 (33.3) | |
| Q3: Characteristic of the etiology of type 2 diabetes | Incorrect/ Don't know | 19 (18.1) | 2 (1.9) | 0.003* |
| | Correct | 44 (41.9) | 40 (38.1) | |
| Q4: Tratamento do diabetes tipo 2 é verdadeira | Incorrect/ Don't know | 3(2.9) | 2 (1.9) | 1.0** |
| | Correct | 60 (57.1) | 40(38.1) | |
| Q5: Effect of insulin on blood glucose levels | Incorrect/ Don't know | 4 (3.8) | 1 (1.0) | 0.646** |
| | Correct | 59 (56.2) | 41 (39.0) | |
| Q6: Physiological actions of insulin | Incorrect/ Don't know | 41(39.0) | 25 (23.8) | 0.711* |
| | Correct | 22 (21.0) | 17 (16.2) | |
| Q7: A person with diabetes is found unconscious; what assumption regarding their blood glucose level should guide your initial actions? | Incorrect/ Don't know | 11 (10.5) | 7 (6.7) | 1.0* |
| | Correct | 52 (49.5) | 35 (33.3) | |
| Q8: Normal fasting blood glucose according to the Brazilian Diabetes Society Guideline (2023): | Incorrect/ Don't know | 11 (10.5) | 6(5.7) | 0.871* |
| | Correct | 52 (49.5) | 36(34.3) | |
| Q9: Factors affecting the accuracy of capillary blood glucose results | Incorrect/ Don't know | 38 (36.2) | 20 (19.0) | 0.279* |
| | Correct | 25 (23.8) | 22 (21.0) | |

| | | | | |
|---|---|---|---|---|
| Q10: Test to determine average blood glucose levels over an extended period | Incorrect/ Don't know | 4 (3.8) | 3 (2.9) | 1.0** |
| | Correct | 59 (56.2) | 39 (37.1) | |
| Q11: Peak effect of Regular insulin | Incorrect/ Don't know | 10 (9.5) | 10 (9.5) | 0.447* |
| | Correct | 53 (50.5) | 32 (30.5) | |
| Q12: Peak effect of Neutral Protamine Hagedorn (NPH) insulin | Incorrect/ Don't know | 22 (21.0) | 15 (14.3) | 1.0* |
| | Correct | 41 (39.0) | 27 (25.7) | |
| Q13: Storage of insulin in use | Incorrect/ Don't know | 43 (41.0) | 36 (34.3) | 0.072* |
| | Correct | 20 (19.0) | 6 (5.7) | |
| Q14: Procedure following needle contamination during preparation for insulin administration. | Incorrect/ Don't know | 3 (2.9) | 11 (10.5) | 0.004* |
| | Correct | 60 (57.1) | 31 (29.5) | |
| Q15: Administration of regular insulin and Neutral Protamine Hagedorn (NPH) in the same syringe | Incorrect/ Don't know | 58 (55.2) | 36 (34.3) | 0.474* |
| | Correct | 6 (5.7) | 6 (4.8) | |
| Q16: Symptom of hypoglycemia | Incorrect/ Don't know | 49 (46.7) | 34 (32.4) | 0.883* |
| | Correct | 14 (13.3) | 8 (7.6) | |
| Q17: Symptom of hyperglycemia | Incorrect/ Don't know | 21 (20.0) | 7 (6.7) | 0.096* |
| | Correct | 42 (40.0) | 35 (33.3) | |
| Q18: Cause of hypoglycemia in an individual with diabetes | Incorrect/ Don't know | 8 (7.6) | 6 (5.7) | 1.0* |
| | Correct | 55 (52.4) | 36 (34.3) | |
| Q19: Cause of hyperglycemia | Incorrect/ Don't know | 30 (28.6) | 17 (16.2) | 0.603* |
| | Correct | 33 (31.4) | 25 (23.8) | |
| Q20: Symptom associated with diabetic ketoacidosis | Incorrect/ Don't know | 7 (6.6) | 4 (3.8) | 1.0** |
| | Correct | 56 (53.3) | 38 (36.2) | |

| | | | | |
|---|---|---|---|---|
| Q21: Causes of diabetic ketoacidosis (coma) in a person with type 1 diabetes | Incorrect/ Don't know | 17 (16.2) | 6 (5.7) | 0.193* |
| | Correct | 46 (43.8) | 36 (34.3) | |
| Q22: Effect of illness on the insulin needs of a person with diabetes | Incorrect/ Don't know | 45 (42.9) | 18 (17.1) | 0.006* |
| | Correct | 18 (17.1) | 24 (22.9) | |
| Q23: Changes in the insulin administration regimen for patients with diabetes undergoing surgery | Incorrect/ Don't know | 38 (36.2) | 33 (31.4) | 0.081* |
| | Correct | 25 (23.8) | 9 (8.6) | |
| Q24: Long-term complications associated with diabetes | Incorrect/ Don't know | 8 (7.6) | 0 | 0.020** |
| | Correct | 55 (52.4) | 42 (38.8) | |
| Q25: Effect of physical and emotional stress on diabetes control | Incorrect/ Don't know | 7 (6.7) | 9 (8.6) | 0.244* |
| | Correct | 56 (53.3) | 33 (31.4) | |
| Q26: Foot care for people with diabetes | Incorrect/ Don't know | 1 (1.0) | 1 (1.0) | 1.0** |
| | Correct | 62 (59.0) | 41 (39.0) | |
| Q27: Procedure for removing a foot callus in a person with diabetes | Incorrect/ Don't know | 20 (19.0) | 20 (19.0) | 0.151* |
| | Correct | 43 (41.0) | 22 (21.0) | |
| Q28: Procedure for a leg abrasion in a person with diabetes | Incorrect/ Don't know | 9 (8.6) | 28 (26.7) | <0.001* |
| | Correct | 54 (51.4) | 14 (13.3) | |
| Q29: Effect of physical exercise on blood glucose levels in people with diabetes (glucose < 250 mg/dL and without ketosis) | Incorrect/ Don't know | 9 (8.6) | 8 (7.6) | 0.705* |
| | Correct | 54 (51.4) | 34 (32.4) | |
| Q30: Effect of increased exercise on food intake (patient has well-controlled type 1 diabetes) | Incorrect/ Don't know | 29 (27.6) | 17 (16.2) | 0.718* |
| | Correct | 34 (32.4) | 25 (23.8) | |
| Q31: Most appropriate INITIAL action to treat a person with type 1 diabetes experiencing hypoglycemia | Incorrect/ Don't know | 54 (51.4) | 24 (22.9) | 0.002* |
| | Correct | 9 (8.6) | 18 (17.1) | |

| | | | | |
|---|---|---|---|---|
| Q32: Nutrients to be calculated in the meal plan for a person with diabetes | Incorrect/ Don't know | 33 (31.4) | 15 (14.3) | 0.139* |
| | Correct | 30 (28.6) | 27 (25.7) | |
| Q33: Main goal in the diet of a person with type 1 diabetes | Incorrect/ Don't know | 32 (30.5) | 15 (14.3) | 0.186* |
| | Correct | 31 (29.5) | 27 (25.7) | |
| Q34: Characteristics of the Somogyi effect | Incorrect/ Don't know | 55 (52.4) | 35 (33.3) | 0.776* |
| | Correct | 8 (7.6) | 7 (6.7) | |
| Q35: Correct sites for insulin injection | Incorrect/ Don't know | 28 (26.7) | 16 (15.2) | 0.657* |
| | Correct | 35 (33.3) | 26 (24.8) | |

Note: *p-value from the chi-square test with Yates' correction; **p-value from Fisher's exact test.

Hierarchical cluster analysis resulted in the formation of three distinct knowledge profiles, presented in Table 3. Their percentages were calculated in proportion to the total number of participants within each profile (percentage = number in the group - professionals or students / total participants in the profile × 100). It is important to note that, although Principal Component Analysis (PCA) does not statistically "confirm" the existence of the clusters in a probabilistic sense, it describes the underlying structure of the responses and the dispersion of individuals in factorial space; this corroborates the theoretical rationale for the group separation and highlights the multidimensional nature of knowledge concerning diabetes.

**Table 3.** Performance by diabetes knowledge profile identified in the hierarchical cluster analysis. Teixeira de Freitas – Bahia, Brazil, 2024.

| Knowledge profile | n | Mean (SD) od correct answers | Median (IQR*) of correct answers | Professionals n (%) | Students n (%) |
|---|---|---|---|---|---|
| Initial | 11 | 15.27 (2.87) | 15 (3.5) | 7 (63.6) | 4 (36.4) |
| Intermediary | 42 | 21.5 (2.4) | 22 (3) | 32 (76.2) | 10 (23.8) |
| High | 52 | 24.37 (2.94) | 24 (4) | 24 (46.2) | 28 (53.8) |

*IQR - Interquartile range; SD - Standard deviation.

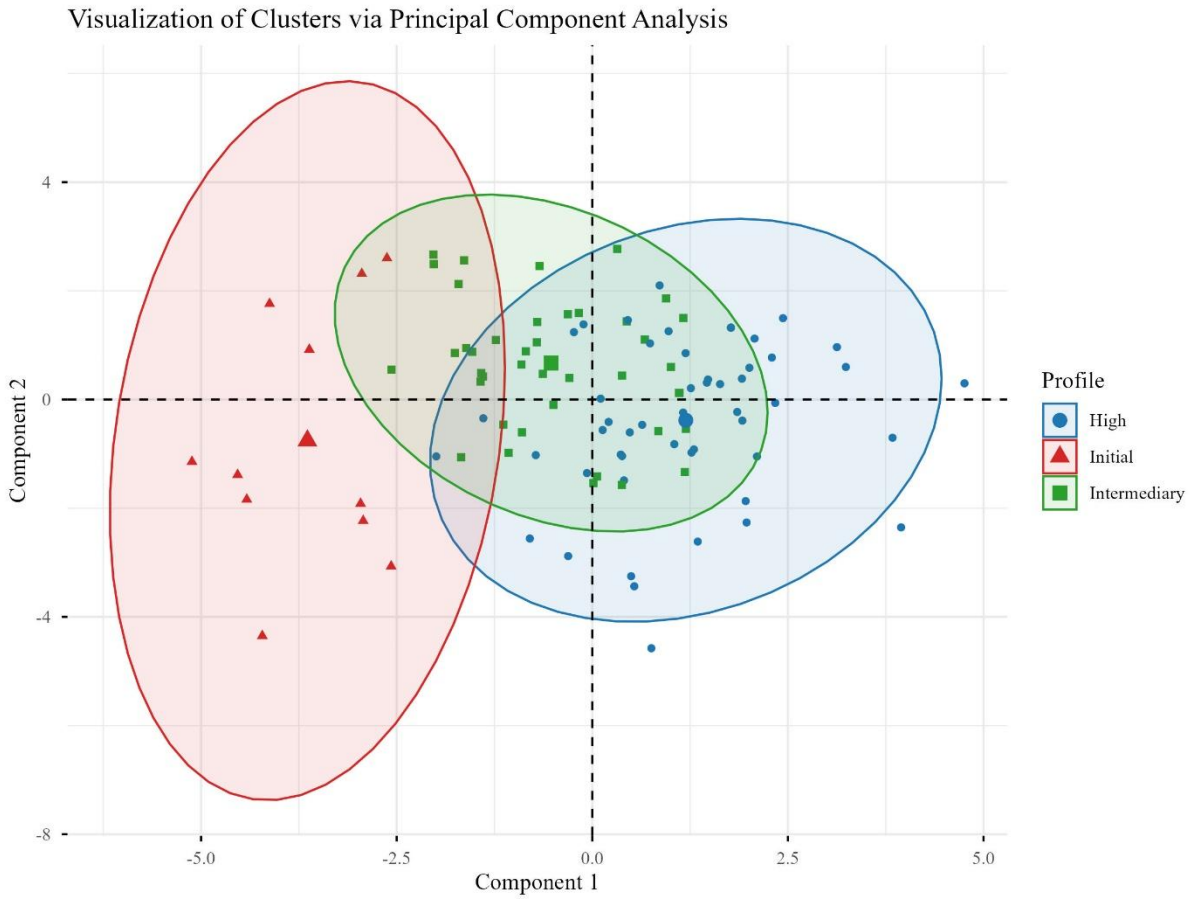
The results show that the initial profile consisted primarily of participants with lower performance and a predominance of healthcare professionals, whereas the high profile exhibited the highest mean

scores and the largest proportion of medical students. The intermediate profile represented a mixed group with average performance and a majority of professionals.

PCA was performed on the binary response matrix to identify variance patterns and natural groupings among the questions. The first two principal components explained 17.18% of the total variance (PC1 = 10.17%; PC2 = 7.00%). Although the cumulative percentage of variance is modest, distinct dispersion of the knowledge profiles was observed in the factorial space, confirming the segmentation obtained through cluster analysis.

The scatter plot (Figure 1) displays three relatively well-defined clusters representing the Initial, Intermediate, and High profiles, with partial overlap between the latter two.

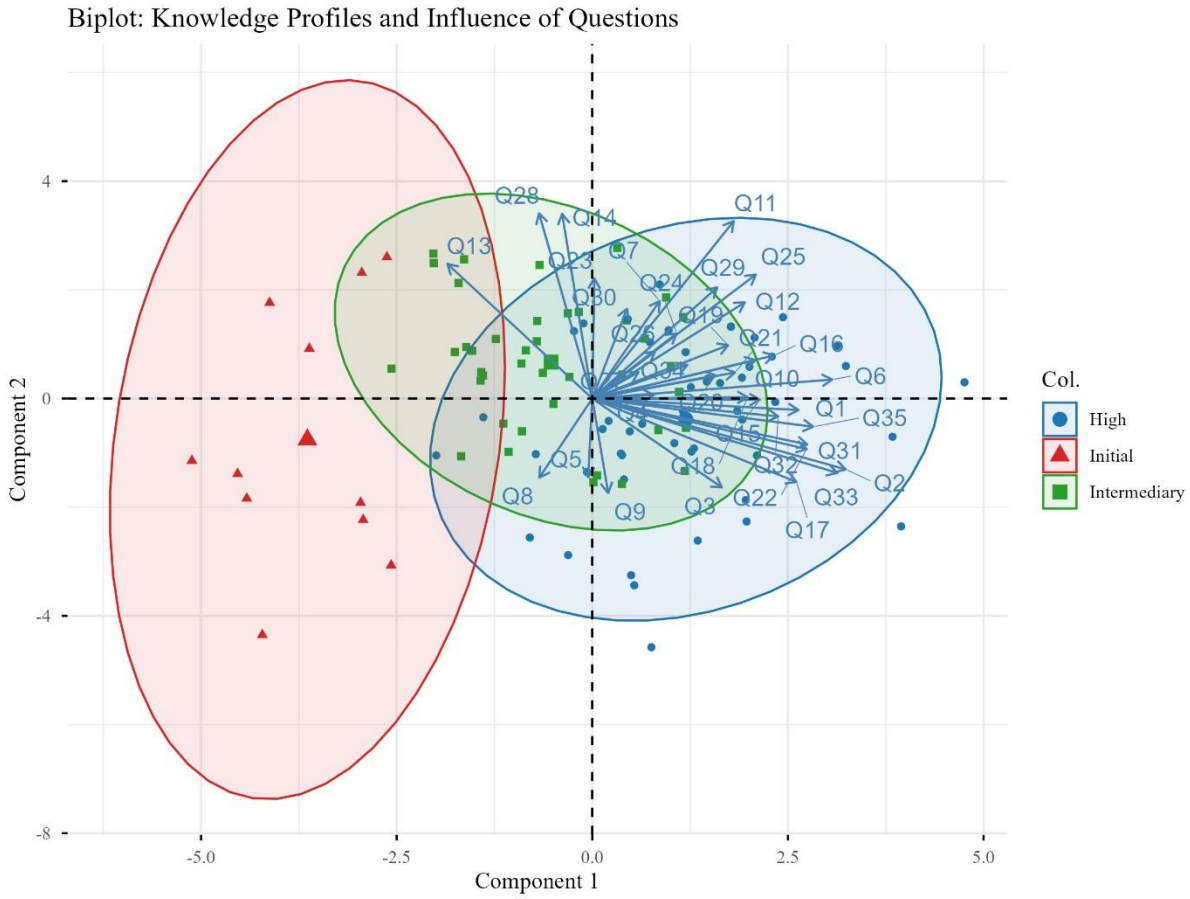
**Figure 1.** Scatter plot of individuals according to principal components and knowledge profiles (clusters). Teixeira de Freitas, Bahia, Brazil, 2024.




The initial profile (n=11) showed the lowest performance (approximately 15 correct answers) and predominated among professionals with more years since graduation (63.6% of the group). In contrast, the high profile (n=52) comprised individuals with better performance (approximately 24 correct answers), with a more balanced distribution between students and younger professionals (53.8% students).

The variable biplot (Figure 2) highlighted the questions that contributed most to the components, indicating the items that best discriminated between knowledge levels.

**Figure 2.** Biplot of variables (questions) and individuals, highlighting the contribution of the items to the first two components. Teixeira de Freitas, Bahia, Brazil, 2024.




The ten questions with the highest factor loadings on Component 1 (PC1), that is, those most strongly associated with the differentiation between performance levels, were: Q2, Q33, Q6, Q35, Q31, Q22, Q1, Q17, Q32, and Q16. These questions exhibited weights ranging from |0.20| to |0.29|. Cronbach's alpha calculated for the items with the highest loadings on the first two components indicated moderate internal consistency, with values of 0.67 (PC1) and 0.52 (PC2), suggesting the presence of multiple cognitive dimensions within the instrument (such as conceptual and clinical knowledge).

## DISCUSSION

This study, by comparing diabetes-related knowledge between healthcare professionals and medical students, revealed a complex landscape with implications for continuing education and clinical practice. The findings reflect contemporary sociodemographic and educational trends and highlight persistent knowledge gaps, including among professionals with more years since graduation, reinforcing

the need for ongoing educational interventions, a point previously emphasized by other authors within the context of the Brazilian healthcare system[24].

The predominance of female participants reflects the feminization of health professions, a trend also observed in medicine, nursing, and other care-related fields [25,26]. This scenario underscores the importance of considering gender issues in training and human resource management policies, as suggested by studies analyzing their impact on the healthcare work environment [27,28].

The professionals were older, had been qualified for longer, and more frequently held postgraduate degrees, indicating participation in professional development activities. However, these factors did not translate into superior theoretical performance, suggesting that continuing education alone may not be sufficient to ensure up-to-date knowledge[29].

The lack of a significant difference in total scores between professionals and students runs counter to the expectation that accumulated experience would confer superiority. This result aligns with studies showing that knowledge recently acquired during undergraduate training can be comparable to the knowledge retained by practicing professionals[22,30], suggesting that clinical experience alone does not guarantee familiarity with the latest guidelines and recommendations.

Although the overall score did not differ between groups, individual question analysis revealed significant differences in specific knowledge domains. This finding reinforces that diabetes knowledge is a multidimensional construct and that assessments based solely on the total score may mask relevant deficiencies[31].

The students' better performance on certain questions likely reflects greater exposure to theoretical content and guidelines recently incorporated into undergraduate curricula, whereas the professionals' superior performance on other items suggests that clinical experience contributes to mastering aspects related to daily management. These results indicate that up-to-date theoretical knowledge and practical experience represent complementary dimensions of professional competence [24,30].

Higher error rates on questions regarding the storage of insulin currently in use, the recognition of hypoglycemia symptoms, and initial management of hypoglycemia highlight gaps in topics directly related to treatment safety and efficacy[31], reinforcing the need for educational strategies targeting these critical areas[24].

Hierarchical cluster analysis identified three distinct knowledge profiles, demonstrating participant heterogeneity regarding mastery of the assessed content. This identification expands the instrument's potential to inform continuing education strategies tailored to diverse learning needs[22,24,30,32,33]. A higher concentration of participants who had graduated longer ago was observed among the lower-performing profiles, while students and younger professionals were more frequently associated with profiles showing

higher numbers of correct answers. These results suggest a possible link between recently updated knowledge and better performance, although a causal relationship cannot be established due to the study's cross-sectional design.

Principal component analysis showed that the first two components explained approximately 17% of the total variance. This result is consistent with instruments assessing complex, multidimensional constructs, such as diabetes knowledge, where distinct domains simultaneously contribute to the observed variability[22].

The moderate internal consistency, as assessed by Cronbach's alpha, reinforces the multidimensional nature of the DBKt, indicating that the instrument covers various domains of diabetes knowledge. Consequently, interpreting the results is more meaningful when considering not only the total score but also performance across the different components, in line with psychometric recommendations for multidimensional instruments[29].

These results underscore the need to strengthen continuing education strategies, particularly for professionals who completed their training longer ago. Although no significant differences in overall scores were observed between professionals and students, the differences identified in specific content areas highlight opportunities to improve continuing education[24]. In this context, using diagnostic knowledge assessments is recommended to identify specific gaps, allowing educational efforts to be targeted at priority topics, such as insulin therapy and acute complications, a strategy that has shown positive results in the literature[11,24].

Finally, the findings reinforce the importance of education-service integration as a strategy to bridge the gap between academic training and clinical practice, while fostering the ongoing professional development of practicing clinicians. This collaboration facilitates the continuous incorporation of scientific evidence and clinical guidelines and is recognized as a fundamental element in enhancing the quality of healthcare[30].

**Study Limitations**

The limitation of this study is the inclusion of participants through non-probabilistic chain sampling, a technique whose selection depends on the contact networks of the participants themselves. This characteristic may favor the inclusion of individuals with similar profiles, reducing the heterogeneity of the sample and limiting its representativeness. In the present study, this aspect may have contributed to the lack of diversity among health professions and the greater participation of nurses, restricting the generalization of results to other professional contexts.

Furthermore, the DBKt needs to be updated to comply with current guidelines regarding the care of people with diabetes. Although the removal of the six questions changed the original composition of

the DBKt, this decision was considered methodologically more appropriate than maintaining items incompatible with current recommendations. It is recognized, however, that this adaptation can influence the psychometric properties of the instrument, such as internal consistency, dimensional structure and comparability of scores with studies that used the original version. Therefore, the results obtained must be interpreted as referring to the adapted version of the instrument, whose purpose was to prioritize content validity and the assessment of knowledge in light of contemporary guidelines, minimizing potential classification biases arising from outdated questions.

**Contributions for the Nursing Area, Health or Public Policy**

The study highlights significant gaps in knowledge regarding diabetes mellitus management, particularly concerning insulin preparation and storage and the recognition of the Somogyi effect, even among experienced healthcare and nursing professionals.

Set within the context of workforce training across various levels of healthcare, this study is significant for filling a scientific gap by identifying specific knowledge profiles among professionals and students. Its aim is to provide a basis for tailoring continuing education strategies, moving beyond a superficial analysis of overall correct-answer scores (knowing versus not knowing) toward a multidimensional understanding of theoretical and practical shortcomings in diabetes care.

In the realm of public health, the research supports managers in implementing evidence-based training programs designed to improve the quality of care for people with diabetes and reduce risks associated with inadequate disease management.

## CONCLUSION

The study revealed that prior knowledge regarding diabetes management among healthcare professionals and medical students was fair, with no statistically significant difference between the groups. Cluster analysis identified three knowledge profiles (basic, intermediate, and advanced) with increasing mean scores. The basic profile consisted primarily of professionals with longer profession exercise, whereas the advanced profile comprised a higher proportion of students and younger professionals, suggesting the influence of recent academic training.

Principal component analysis confirmed the multidimensional nature of the knowledge, with approximately 17% of the variance explained and moderate internal consistency, indicating that various cognitive dimensions influence performance on the instrument. Overall, the results underscore the need for continuous training for professionals and students regarding the prevention, pathophysiology, signs, symptoms, and treatment of hypoglycemia, as well as the diagnosis and treatment of diabetes and its complications. Furthermore, the study identified a need to update the DBKt in line with new Brazilian diabetes guidelines and to develop complementary instruments to assess the knowledge of other

healthcare professionals.

The findings point to crucial implications for clinical practice and highlight gaps in disease management, even among more experienced professionals. Regarding education, the study indicates a need to review and strengthen health science curricula, particularly in nursing, by focusing on topics with high error rates to ensure a robust and up-to-date educational foundation. Finally, regarding research, the results suggest the importance of continuously investigating and developing assessment tools and educational materials, ensuring they are validated and updated in accordance with the latest clinical guidelines, as evidenced by the outdated nature of some questions in the instrument used.

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**Data Availability:** All data are included in the manuscript.

**Declaration of the use of generative artificial intelligence:** We declare that, during the preparation of the article “Knowledge Profiles on Type 1 and Type 2 Diabetes Mellitus among Healthcare Professionals

and Medical Students" for the Revista de Enfermagem da UFJF, the authors used *Microsoft Copilot* to assist in developing and correcting the programming commands employed in the data analysis performed using the R programming language. After using the tool, the authors reviewed and adjusted the content as necessary and assume full responsibility for the version presented in this publication.

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