Psychometric properties of Persian version of diabetes health literacy scale (DHLS) in patients with type 2 diabetes

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Abstract

Background: The purpose of this study was to investigate the psychometric properties of the Persian version of Diabetes Health Literacy Scale in type 2 diabetic patients.

Method: This cross-sectional study was conducted in 2021 in 1040 patients with type 2 diabetes in eastern Iran. Participants were selected by proportional stratified sampling method. The validity of DHLS was investigated through qualitative face validity, qualitative content validity, and structural validity (exploratory factor analysis and confirmatory factor analysis). The reliability of DHLS was checked by Cronbach’s alpha coefficient, McDonald omega coefficient, and test–retest.

Results: In exploratory factor analysis, 3 factors with eigenvalues greater than 1 were extracted, explaining 68.57% of the variance. These factors entered the confirmatory factor analysis, none of the questions were removed, and all questions had factor loading above 0.4. Cronbach’s alpha coefficient and McDonald omega coefficient of DHLS were 0.919 and 0.922. Also, the Intraclass correlation coefficient of DHLS was 0.957. Finally, the DHLS was approved with 14 questions and the three subscales of Informational Health Literacy (6 items), Numerate Health Literacy (5 items), and Communicative Health Literacy (3 items).

Conclusions: DHLS with 14 questions and the three subscales is a valid and reliable tool for examining diabetes health literacy in people with type 2 diabetes.

Keywords: Psychometric, Validity, Reliability, Diabetes health literacy scale, DHLS, Type 2 diabetic

Background

The increase in diabetes is a fundamental problem in healthcare systems around the world, and diabetes is considered one of the most challenging and highest chronic diseases [1, 2]. It’s predicted that the total number of people with diabetes will reach 643 million by 2030 and by 2045 to 783 million [1]. The tenth leading cause of death in Iran is diabetes [3]. Currently, the prevalence of diabetes in the general Iranian population is 2–3%, while the prevalence in people over the age of 30 is 7% [3]. Side effects of diabetes often cause high financial costs and reduced quality of life, and the care and treatment of diabetes patients accounts for about 4% of the health budget and estimated that the medical cost of a patient diabetes is 2 to 5 times more than healthy people [4].

Although there is no definitive treatment, it is possible to prevent and manage the type 2 diabetes [5–7]. Health literacy is one of the most influential factors in controlling and
preventing diabetes [5]. The World Health Organization has identified health literacy as one of the biggest determinants of health [8]. It has also advised the countries of the world to create a community to promote health literacy in different societies [8]. Health literacy refers to cognitive and social skills that include the motivation and ability of individuals to achieve the perception and use of information to maintain and improve their health [9].

Studies have shown that low health literacy can have adverse effects on chronic disease, so there is a need to improve individuals' health literacy levels to manage their health and make health decisions [10–12]. The results of some studies in Iran showed that most diabetic patients do not have sufficient health literacy [13, 14]. People with low health literacy in the management of diseases such as diabetes are less successful in implementing self-care behaviors. Diabetic patients must have the necessary knowledge and awareness of self-care behaviors, and health literacy plays an important role in the control of diabetes [15, 16].

To examine health literacy in patients with diabetes, a proper instrument is needed. In Iran, several measures (such as HELIA and TOHFLA) are used to assess health literacy [17, 18], but these instruments examine general health literacy and are not specifically designed for patients with type 2 diabetes. One of the important stages of any research is data collection, which requires the use of appropriate tools [19]. To examine the status of diabetes health literacy and to design effective intervention programs, it is necessary to design and assess diabetes-specific tools. Therefore, it is necessary to create specialized tools to investigate the health literacy of people with diabetes.

The aim of this study was to examine the psychometric properties of Persian version of diabetes health literacy scale (DHLS) among type 2 diabetic patients. This scale was designed for people with diabetes and approved by Lee [20]. The purposes of this study were to:

1. Translating and determining the cultural adaptation of the DHLS in patients with type 2 diabetes.
2. Determine of qualitative face validity, qualitative content, and structural validity (using exploratory factor analysis and confirmatory factor analysis) of the DHLS in patients with type 2 diabetes.
3. Determine the reliability of the DHLS in patients with type 2 diabetes.

Methods

Design and participants

The purpose of this cross-sectional study was to investigate the psychometric properties of the Persian version of DHLS in 1040 patients with type 2 diabetes in eastern Iran in 2021.

Sample size

To perform structural validity (exploratory factor analysis and confirmatory factor analysis), the sample size of 100 is weak, 200 is relatively good, 300 is good, 500 is very well, and 1000 and more is considered excellent [21, 22]. As recommended exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are not performed on the same dataset as this yields high danger of overfitting [23]. So, in this study, EFA was performed on 300 participants and CFA was performed on 1040 participants.

Sampling method

The sampling method in this study was proportional stratified sampling method. Initially, the number of health centers and the population of each center in three cities in eastern Iran were determined (Cities were selected by random method). In the next step, in each city, each health center was considered as a stratum and the sample size was determined based on the population of each class. In the following, samples from each center were randomly selected from patients who met the inclusion criteria.

The inclusion criteria in this study were people with type 2 diabetes disease based on laboratory results, had type 2 diabetes for more than a year, and had a tendency to participate in this study and fill out an informed consent form. Questionnaires with incomplete information were removed in the data analysis step.

Instruments

1. Demographic questionnaire: This questionnaire includes questions such as sex, age, job status, marital status education level, age of onset of diabetes, and duration of the diabetes.
2. Diabetes health literacy scale (DHLS): This scale consists of 14 questions, and three subscales of Informational Health Literacy (7 items), Numerate Health Literacy (4 items), and Communicative Health Literacy (3 items). Questions of this scale were measured with a five-option Likert scale (not really = 1, slightly = 2, moderately = 3, quite a lot = 4, very much = 5), and higher scores on the DHLS and each subscale indicate better health literacy status. This questionnaire was designed and confirmed by Lee, and the validity of the scale have been verified by EFA and CFA. In Lee study, the Cronbach’s alpha coefficient of total scale and three subscales of Informational Health Literacy, Numerate Health Literacy, and Communicative Health Literacy were equal to 0.91, 90, 0.80, and 0.85, respectively. Also, the Intraclass correlation coefficient of total DHLS and three
subscales of Informational Health Literacy, Numerate Health Literacy, and Communicative Health Literacy were equal to 0.89, 0.85, 0.85, and 0.80, respectively [20].

**Translation and cultural adaptation**

First, the consent of the main designer of the questionnaire was obtained. In the first step, the English version of the questionnaire was translated into Persian by two experts. In the following, we reviewed two versions of the translated questionnaire and created the Persian version of the questionnaire. In the second step, the Persian version of questionnaire was translated into English by two experts. After reviewing the two versions, an English version of the questionnaire was produced. In the third stage, the English version of the questionnaire was compared with the original version of the questionnaire.

**Validity assessment**

When the standard questionnaire is used and translated, quantitative face validity and quantitative content validity are not required to evaluate the psychometric standard questionnaire [24]. In this study, due to the use of a standard questionnaire, the validity of the questionnaire was investigated only by qualitative face validity and qualitative content validity.

**Face and content validity**

To examine the qualitative face validity, the questionnaire was provided to a number of target groups and the questionnaire was investigated in terms of ambiguity, relevance, suitability and difficulty of each question and finally the required modification were taken. To examine the qualitative content validity, the questionnaire was given to 9 specialists in public health and health education and the questionnaire was investigated in terms of grammar, the use of appropriate words, the importance of items, time required to answer each question, placement of items in the proper place, and finally the required modification were taken.

**Structural validity**

**EFA**

Before the conducting of EFA, Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of Sphericity were used to check adequacy of the sample and the suitability of data [25, 26]. In the EFA stage, the minimum factor loading of 0.4, eigenvalues more than 1, and scree plot were used to explore the number of potential latent factors [27, 28]. When the identified factors was explain at least of 60% of the variance, the results of EFA was consider acceptable [29, 30].

**CFA**

In CFA stage, at first, the Mahalanobis statistical index was used for assessed the outlier's data and then, skewness and kurtosis were used for evaluating the data normality. The following indicators were used to assess goodness-of-fit of the model. These indicators consist of root mean square error of approximation (RMSEA), chi-square ratio to degree of freedom (χ²/df), parsimony comparative fit index (PCFI), parsimonious normed fit index (PNFI), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), incremental fit index (IFI), comparative fit index (CFI), relative fit index (RFI), normed fit index (NFI), and parsimony goodness-of-fit index (PGFI) [31–33]. Standard goodness-of-fit indexes included χ²/df < 5, RMSEA < 0.08, AGFI > 0.8, PCFI > 0.5, PGFI > 0.5, PNFI > 0.5, and indices of GFI, CFI, IFI, RFI, GFI, and NFI greater than 0.9 [31–34].

**Reliability assessment**

In this study, Cronbach’s alpha coefficient, McDonald omega coefficient, and test–retest were used to evaluate the reliability of the questionnaire. Results reported the Cronbach’s alpha coefficient of ranging from 0.70 to 0.95 is good [35, 36]. Also, the Intraclass Correlation Coefficient (ICC) was used to assess test–retest. The amount of ICC higher than 0.80 is acceptable [37]. To review the reliability, questionnaires were provided to 30 participants. Also, to review the test–retest, the questionnaire was given to the participants twice (the second phase was completed after 2 weeks).

**Data analysis**

In this study, EFA was performed using SPSS _v_20 software. At this stage, the factors extracted in the EFA stage were examined by using AMOS _v_24 software. Also, Pearson correlation was used to investigate the correlation between DHLS factors. The Cronbach’s alpha coefficient and McDonald’s omega coefficient were calculated using the SPSS _v_20 software and JASP _v_0.11.1 software, respectively.

**Results**

**Descriptive characteristics**

The mean (± standard deviation) age of participants in this study was 52.63 (± 14.70). The mean (± SD) age of onset of diabetes and duration of the diabetes were 43.58 (± 9.62) and 8.69 (± 6.80), respectively. The majority of participants in this study were men (n = 523, 50.3%) and married (n = 619, 59.6%). Most of the education level of participants were high school/diploma (n = 315, 30.3%) and middle school (n = 248,
23.8%). The job status of the majority of participants were housewives (n = 421, 40.6%) and self-employed (n = 238, 22.9%) (Table 1).

**Validity assessment**

First, the translation and cultural adaptation process of the questionnaire was carried out. Then, the questionnaire was checked using qualitative face validity and qualitative content validity, and four questions were modified.

**EFA**

First, the data were analyzed using EFA. The results of KMO and Bartlett’s Test of Sphericity showed that the sample size was sufficient for this section (KMO = 0.877, Bartlett’s test: p < 0.001, $\chi^2 = 2508.555$, df = 91). Also, based on the results of EFA, 3 factors with eigenvalues greater than 1 were extracted, explaining 68.57% of the variance. These factors were similar to the original questionnaire factors. Only in this study, a question (Question 7: When a change occurs in my personal plan, I can change the appointment date or time for a medical checkup) moved from factor 1 (F1: Informational health literacy) to factor 2 (F2: Numerate health literacy) (Tables 2, 3; Fig. 1).

**CFA**

In this section, the factors extracted in the EFA stage were evaluated by CFA. All goodness-of-fit indexes had a standard rate (for example: $\chi^2$/$df$ = 4.604, RMSEA = 0.059, GFI = 0.955, CFI = 0.959) and the final model was confirmed with three factors and 14 questions (Table 4). At this stage, none of the questions were removed and the factor lodging of all questions were above 0.4 (Table 5, Fig. 2).

### Table 1 Frequency distribution of demographic characteristics (n = 1040)

| Variables          | N   | %  |
|--------------------|-----|----|
| Sex                |     |    |
| Men                | 523 | 50.3|
| Women              | 517 | 49.7|
| Marital status     |     |    |
| Married            | 619 | 59.6|
| Single             | 420 | 40.4|
| Education level    |     |    |
| Illiterate         | 30  | 2.9 |
| Elementary school  | 167 | 16.1|
| Middle school      | 248 | 23.8|
| High school/diploma| 315 | 30.3|
| Associate or bachelor's degree | 229 | 22.0|
| Master's degree or high degree | 51  | 4.9 |
| Job                |     |    |
| Housewife          | 421 | 40.6|
| Employed           | 123 | 11.8|
| Self-employed      | 238 | 22.9|
| Unemployed         | 39  | 3.8 |
| laborer            | 88  | 8.5 |
| Retired            | 129 | 12.4|

### Table 2 The three-factor structure of the Persian version of DHLS

| Component | Initial Eigenvalues | Extraction sums of squared loadings | Rotation sums of squared loadings |
|-----------|---------------------|------------------------------------|----------------------------------|
|           | Total % of variance | Cumulative %                       | Total % of variance | Cumulative % | Total % of variance | Cumulative % |
| 1         | 6.083               | 43.452                             | 6.083                 | 43.452       | 4.197               | 29.978       |
| 2         | 1.970               | 14.074                             | 1.970                 | 14.074       | 3.343               | 23.880       |
| 3         | 1.546               | 11.043                             | 1.546                 | 11.043       | 2.059               | 14.710       |
| 4         | 0.786               | 5.618                              | 74.186                | 0.712        | 5.084               | 79.270       |
| 5         | 0.544               | 3.888                              | 83.157                | 0.544        | 3.888               | 83.157       |
| 6         | 0.432               | 3.085                              | 86.242                | 0.432        | 3.085               | 86.242       |
| 7         | 0.407               | 2.910                              | 89.152                | 0.407        | 2.910               | 89.152       |
| 8         | 0.394               | 2.814                              | 91.966                | 0.394        | 2.814               | 91.966       |
| 9         | 0.290               | 2.070                              | 94.036                | 0.290        | 2.070               | 94.036       |
| 10        | 0.267               | 1.911                              | 95.947                | 0.267        | 1.911               | 95.947       |
| 11        | 0.227               | 1.624                              | 97.571                | 0.227        | 1.624               | 97.571       |
| 12        | 0.198               | 1.413                              | 98.983                | 0.198        | 1.413               | 98.983       |
| 13        | 0.142               | 1.017                              | 100.000               | 0.142        | 1.017               | 100.000      |

Extraction method: principal component analysis
Reliability assessment
Cronbach’s alpha coefficient and McDonald omega coefficient of DHLS were 0.919 and 0.922. Cronbach’s alpha coefficient of Informational health literacy (F1), Numerate health literacy (F2), and Communicative health literacy (F3) were 0.865, 0.879, and 0.784, respectively. McDonald omega coefficient of Informational health literacy (F1), Numerate health literacy (F2), and Communicative health literacy (F3) were 0.871, 0.881, and 0.800, respectively. The ICC of DHLS was 0.957 (Table 6). The results of Pearson correlation analysis showed that there was a significant positive correlation between the factors of DHLS (Table 7).

Discussion
A key issue to consider when considering health literacy tools is the range of concepts that need to be measured. According to a recent systematic review of measurement characteristics [38], previously reported instruments for measuring the health literacy of diabetic patients measure limited ranges of basic skills (such as reading and comprehension), with the exception of the Health Literacy Scale [39] and the Health Literacy Questionnaire [40]. Although these two scales measure more than basic skills, they have been criticized for their inability to measure counting. The Health Literacy Questionnaire contains 44 items, making it less likely to use it in Clinical environments. Unlike existing tools, the DHLS assessed in this study includes three dimensions of health literacy, including Informational Health Literacy, Numerate Health Literacy, and Communicative Health Literacy. In other words, health professionals can use DHLS to assess their patients’ diabetes health literacy more comprehensively. Evaluated levels of three dimensions of health literacy can be used to adapt information education for diabetics and thus optimize educational outcomes.

Table 3 Rotated factor matrix of the Persian version of DHLS

| Items | Component |
|-------|-----------|
| T1    | 0.742     | 0.264 | 0.004 |
| T2    | 0.884     | 0.143 | 0.123 |
| T3    | 0.902     | 0.134 | 0.148 |
| T4    | 0.842     | 0.262 | 0.099 |
| T5    | 0.815     | 0.049 | 0.255 |
| T6    | 0.603     | 0.521 | 0.105 |
| T7    | 0.348     | 0.710 | 0.183 |
| T8    | 0.256     | 0.616 | 0.305 |
| T9    | 0.162     | 0.864 | 0.051 |
| T10   | 0.192     | 0.776 | 0.186 |
| T11   | 0.018     | 0.773 | 0.008 |
| T12   | 0.021     | 0.224 | 0.741 |
| T13   | 0.212     | 0.076 | 0.840 |
| T14   | 0.136     | 0.083 | 0.721 |

Extraction method: principal component analysis
Rotation method: Varimax with Kaiser Normalization
 Rotation converged in 5 iterations

Table 4 The model fit indicators of the Persian version of DHLS

| Goodness of fit indices | Confirmatory factor analysis | Acceptable value |
|-------------------------|-----------------------------|------------------|
| $\chi^2$                | 331.470                     | –                |
| df                      | 72                          | –                |
| $X^2$/df                | 4.604                       | < 5              |
| p-value                 | 0.000                       | $p > 0.05$       |
| CFI                     | 0.959                       | > 0.9            |
| GFI                     | 0.955                       | > 0.9            |
| RMSEA                   | 0.059                       | < 0.08           |
| IFI                     | 0.959                       | > 0.9            |
| RFI                     | 0.934                       | > 0.9            |
| NFI                     | 0.948                       | > 0.9            |
| PNFI                    | 0.750                       | > 0.5            |
| PCFI                    | 0.758                       | > 0.5            |
| PGFI                    | 0.655                       | > 0.5            |
| AGFI                    | 0.934                       | > 0.8            |

Fig. 1 Scree plot of the factor analysis of the Persian version of DHLS
properties with high reliability and excellent convergence properties as well as factorial validity.

In our study, the overall internal consistency (Cronbach’s alpha coefficient) of the Persian version of DHLS was excellent. Due to the consistency of internal consistency, Cronbach’s alpha increases when the scale contains more items [41]. Although DHLS is a relatively short tool, in this study, Cronbach’s alpha for DHLS was exceeded 0.8. This means that the items in each DHLS subscale measure exactly the same underlying attribute [42].

**Strength and limitations**

One of the limitations of this study was the COVID-19 pandemic, which led to a slow process of data collection. Another limitation of this study was that the information was completed in self-reports, which may have some errors. The first strength of this study was that the psychometric process was performed by the face validity, content validity, structure validity (EFA and CFA), and reliability (Cronbach’s alpha coefficient, McDonald’s omega coefficient and ICC). The second strength of this study was the large sample size. The third strength of this study was that the samples were selected from three different cities.

**Conclusion**

Finally, in this study, the DHLS was approved with 14 questions and the three subscales of Informational Health Literacy (6 items), Numerate Health Literacy (5 items), and Communicative Health Literacy (3 items). The Persian version of DHLS is a valid and reliable tool.

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**Table 5** Factor loadings of the Persian version of DHLS

| Subscales                         | Items                                                                 | Factor loadings |
|-----------------------------------|-----------------------------------------------------------------------|-----------------|
| F1: Informational health literacy | T1: I can read and understand booklets and educational materials related to diabetes | 0.778           |
|                                   | T2: I can understand the written information given by the physician about diabetes treatment or an examination | 0.646           |
|                                   | T3: I can receive and print the results of my diabetes test through the website that has been announced by the lab, hospital, etc. | 0.721           |
|                                   | T4: I can understand the information about diabetes that I sought from different sources (for example booklets, TV, Internet, etc.) | 0.786           |
|                                   | T5: I understand the information provided by the health-care provider on diabetes management | 0.651           |
|                                   | T6: I can earn reliable information about diabetes from different sources | 0.736           |
| F2: Numerate health literacy      | T7: When a change occurs in my personal plan, I can change the appointment date or time for a medical checkup | 0.741           |
|                                   | T8: I can calculate the next time taking my diabetes medications | 0.602           |
|                                   | T9: I can determine the amount of carbohydrate content per meal from the nutrition label on food packaging | 0.400           |
|                                   | T10: Based on the results of my blood glucose test, I can understand whether my blood glucose levels are normal or not | 0.822           |
|                                   | T11: I can understand information about diabetes that are provided as ratios, probabilities or graphs | 0.772           |
| F3: Communicative health literacy | T12: When I have a question about diabetes, I usually ask a health-care provider | 0.616           |
|                                   | T13: I can explain the condition of my diabetic disease for health care provider | 0.673           |
|                                   | T14: When I eating out with my friends or colleagues, I can explain the reason why I should have a diabetic diet | 0.596           |
for measuring the health literacy status in patients with type 2 diabetes in Iran.

**Abbreviations**

DHLS: Diabetes health literacy scale; EFA: Exploratory factor analysis; CFA: Confirmatory factor analysis; KMO: Kaiser–Meyer–Olkin; F1: Informational health literacy; F2: Numerate health literacy; F3: Communicative health literacy; RMSEA: Square error of approximation; x2/df: Chi-square ratio to degree of freedom; PCFI: Parsimony comparative fit index; PNFI: Parsimonious normed fit index; GFI: Goodness of fit index; AGFI: Adjusted goodness of fit index; IFI: Incremental fit index; CFI: Comparative fit index; RFI: Relative fit index; NFI: Normed fit index; PGFI: Parsimony goodness-of-fit index.

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**Author contributions**

Authors MM, AJ, AA, MD, ZZ and MGh designed the study. MM, AJ, AA, and MGh participated in the conception of the study. MD, ZZ and AJ managed and conducted the statistical analyses and interpreted the data. AJ and MM wrote the first draft and AJ, MM, and AA revised it to make the final manuscript. All authors have approved the final manuscript.

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**Availability of data and materials**

All data generated or analysed during this study are included in this published article.

**Declarations**

**Ethics approval and consent to participate**

This study is based on a research project approved by Ethics Committee of Gonabad University of Medical Sciences with the code of ethics IR.GMU.REC.1400.092. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable. Written Informed Consent was obtained from all subjects.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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**Table 6** Descriptive statistics of the Persian version of DHLS

| Subscales                                      | Item | Range | Cronbach's alpha coefficients | McDonald's omega coefficients | Intraclass correlation coefficient (ICC) | 95% confidence interval | P-value |
|-----------------------------------------------|------|-------|--------------------------------|-------------------------------|----------------------------------------|------------------------|---------|
| Factor 1: Informational health literacy       | 6    | 6–30  | 0.865                          | 0.871                         | 0.976                                  | 0.950                  | 0.989   | < 0.001 |
| Factor 2: Numerate health literacy           | 5    | 5–25  | 0.879                          | 0.881                         | 0.921                                  | 0.834                  | 0.962   | < 0.001 |
| Factor 3: Communicative health literacy      | 3    | 3–15  | 0.784                          | 0.800                         | 0.911                                  | 0.813                  | 0.957   | < 0.001 |
| Total diabetes health literacy scale (DHLS)  | 14   | 14–70 | 0.919                          | 0.922                         | 0.957                                  | 0.910                  | 0.980   | < 0.001 |

**Table 7** Pearson correlation between DHLS subscales

| Subscales                                      | Informational health literacy | Numerate health literacy | Communicative health literacy |
|-----------------------------------------------|-------------------------------|--------------------------|-------------------------------|
| Informational health literacy                 | 1                             |                          |                               |
| Numerate health literacy                      | 0.678*                        | 1                        |                               |
| Communicative health literacy                 | 0.513*                        | 0.500*                   | 1                             |

* Correlation is significant at the 0.01 level (2-tailed)
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