ABSTRACT

Background: Low health literacy (HL) of patients has obtained more attention as a risk factor for poor adherence to treatment and adverse outcomes in chronic disease's management particular in diabetes care. Diabetes Numeracy Test-15 (DNT-15) has been developed specifically for this purpose. The objective of the current study is to evaluate psychometric properties of Iranian (Persian) version of the DNT-15.

Methods: The shortened version of the DNT (15-items) was completed by 120 patients with diabetes. The Kuder–Richardson Formula 20 for internal consistency was conducted. Content validity, criterion-related validity, and construct validity were also evaluated.

Results: The average score on the DNT was 72% and took an average of 25 minutes to complete. The DNT-15 had a very good internal reliability (KR-20 = 0.90) and also content validity (content validity ratio: 0.89 and content validity index: 0.86).

Conclusions: The DNT-15 (Persian version) is a reliable and valid measure of diabetes-related numeracy skills for Iranian patients with diabetes; however, additional studies are needed to further explore the association between diabetes-specific numeracy and acculturation and their impact on diabetes-related outcomes in Iranian population.

Keywords: Diabetes, health literacy, Iran, validity and reliability

INTRODUCTION

The World Health Organization has defined health literacy (HL) as “the cognitive and social abilities which determine the incentive and ability of individuals to increase access to understand and use information in ways, which promote and preserve good health.”[1] The HL of patients has obtained more attention as a risk factor for poor adherence to treatment and adverse outcomes in chronic disease’s management particular in diabetes care.[2‑5] Diabetes is the most common metabolic disease with a dramatic increase rate of prevalence throughout the world,[6] which has an important impact on the public health and quality of life of the patients.[7]

There is a developing frame of the literature that discovers the association between HL and health outcomes in people with diabetes. Older studies of low HL reported adverse effects on diabetes-related health outcomes,[8,9] however, more recent studies showed no association between HL levels and intensity, frequency or incidence of outcomes, and thus the effect of HL on the health of people with diabetes is yet unclear.[10,11] Based
on national reports, the prevalence of diabetes has been raised during three decades in Iran and also a recent national survey about HL has shown that majority of people has inadequate knowledge. However, there are different tools to measure HL and numeracy skills in general population in different languages, only Diabetes Numeracy Test-15 (DNT-15) has been developed specifically to measure numeracy skills in patients with diabetes as first scale by Huizinga et al., in English language. With regard to lacking of appropriate measurement tool for patients with diabetes in Persian (Farsi) language, this study aimed to provide evidence for the psychometric properties of the Iranian (Persian language) version of DNT-15.

**METHODS**

The questionnaire

The DNT was designed to evaluate nutrition, exercise, glucose monitoring, oral medication, and insulin skills that patients may encounter during daily diabetes self-management. There are three nutrition items fixing on nutrition label interpretation and carbohydrate counting. One exercise items evaluate carbohydrate intake and insulin adjustment for exercise time. Blood-glucose monitoring skills are evaluated by three items about number hierarchy, gllicated hemoglobin, and calculating supplies needed. Eight items assess the oral medication use and insulin use. Oral medication (one question) use refill patterns and dates, and oral titration schemes and insulin use (seven questions) including interpretation of syringes, correction or sliding-scale insulin use, insulin adjustment for carbohydrate intake, and titration instructions [Table 1]. Items are scored as binary outcomes – correct or incorrect – and no partial credit is given. There is no time limit for the administration of the scale. Many patients with diabetes use calculators; therefore, participants were allowed to use calculators during the administration of the DNT to emulate real-life circumstances. DNT scores are reported as percent correct (with a possible range of 0% to be 100%).

**First phase: Forward translation**

In this phase, the original questionnaire was translated by two independent health professionals from English to Persian. After translation, by consultation with the principal investigators, the results were rechecked. Finally, they achieved a precision translation for the questionnaire.

**Second phase: Backward translation**

In this phase, the questionnaire that translated in the previous step, gave to two professional translators whose native language were English, and they are sufficient dominance in Persian language. The translators did not communicate with one another and did not know the original English version. Translated versions by consultation with the principal investigators of conversion backward translation were combined.

**Third phase: Expert groups**

In this phase, a group of experts was reviewed, all phases, including verification and cross-cultural equivalent (cross-cultural equivalence). Cultural equivalent to the word (semantic), a term equivalent (idiomatic), and equivalent experience (experiential), and conceptually equivalent (conceptual) were performed by an expert panel. This group included experts in diabetes, certified diabetes educators, methodologist, primary care providers, and registered dietitians, behavioral researchers in diabetes, and literacy and numeracy experts. Finally, the DNT was to address the clarity of items for patients with diabetes. Ten cognitive response interviews were conducted with patients with diabetes to evaluate each item. Interviewees were asked specific questions about each item to evaluate the understandability of the wording. If an item was unclear, the interviewee was told the purpose of the item and then encouraged to suggest a different format or wording. In response to the interviews, the scale was reformatted and slightly reduced to the final 15-items. Reliability was evaluated by internal consistency (Kuder-Richardson 20), and validity was evaluated through content validity ratio (CVR) and content validity index (CVI).

**Participant selection**

A convenience sample of 120 patients with diabetes was interviewed in the diabetes clinic affiliated to Institute of Endocrinology and Metabolism an item at clinic visits. Any person diagnosed with Type 1 and or Type 2 diabetes which was able to read (at least eight grades)

| Table 1: Description of diabetes numeracy test items |
|-----------------------------------------------|
| **Domain**                  | **Question number** |
| Nutrition                   | 1-3                |
| Exercise                    | 4                  |
| Blood glucose monitoring    | 5-7                |
| Oral medication use         | 8                  |
| Insulin use                 | 9-15               |
| Math problem type           |                    |
| Addition/subtraction        | 8,15               |
| Multiplication/division     | 1,6,10             |
| Fractions/decimals          | 2,3                |
| Multi-step mathematics      | 4, 12-15           |
| Time                        | 7                  |
| Numeration/counting/hierarchy | 5, 9, 11          |
and speak Persian language. Potential participants were excluded if they corrected visual acuity was >20/50 using a Rosenbaum Pocket Vision Screener, or if they had a diagnosis of significant dementia, psychosis, or blindness.

**RESULTS**

The characteristics of participants demonstrated in Table 2. The mean age was 51.2 years, and 64% of the participants were male. The 15-item DNT took an average of 25 min to complete. The average score (±standard deviation) on the DNT was 72% ±22. Difficult issues for participants included titration schemas, food label interpretation, insulin adjustment instructions, and items that required multi-step math (e.g., calculating insulin dosage based on carbohydrate intake and glucose level). Two commonly used methods for sliding-scale insulin adjustment instructions are displayed: Questions 2, 5, 6, 7, 8, 9, and 11 were answered accurately respectively by 89.1%, 78.2%, 87.4%, 72.3%, 85.7%, 84%, and 83% of participants for this study. However, questions 14 and 15, which required patients to interpret a word problem and apply multiple numerical steps to determine their insulin dosage, was only answered correctly, respectively by 41%, 54% of the participants. The 15-item Persian version of the DNT has highly reliable, as determined by internal consistency Kuder–Richardson (KR-20 = 0.90). Content validity was examined by the expert panel (CVR: 089 and CVI: 0.86).

### Table 2: Patient characteristics (n=120)

| Characteristic          | Mean±SD or n (%) |
|-------------------------|------------------|
| Age                     | 51.211           |
| Gender                  |                  |
| Male                    | 64 (53.3)        |
| Female                  | 56 (46.4)        |
| Education               |                  |
| Diploma                 | 24 (20.0)        |
| High diploma            | 20 (16.7)        |
| Bachelor                | 49 (40.8)        |
| Masters                 | 22 (18.3)        |
| PhD                     | 5 (4.2)          |
| Duration of diabetes    |                  |
| 5 year                  | 35 (29.5)        |
| 5-10 year               | 32 (26.7)        |
| 10-15 year              | 30.0             |
| >15 year                | 17 (14.2)        |
| Drug use                |                  |
| Insulin                 | 86 (71.7)        |
| Tablet                  | 34 (28.3)        |

There are also clinical implications that can be learned from this study. We learned that the framing of instructions was very important in predicting patient performance. For example, study participants had a difficult time with the multi-step math required to calculate a correction dosage of insulin when instructions were presented as a sequence of sentences. This is with line with other studies. This item was encompassed to mirror clinical practice regarding how patients are currently instructed to take their insulin. This example provides an important lesson for health care providers and educators in effective communication styles for all clinical care recommendations.

**CONCLUSIONS**

The Persian (Farsi) version of DNT-15 is a reliable and valid tool to measure of diabetes-specific numeracy skills for patients with diabetes.

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**REFERENCES**

1. Inoue M, Takahashi M, Kai I. Impact of communicative and critical health literacy on understanding of diabetes care and self-efficacy in diabetes management: A cross-sectional study of primary care in Japan. BMC Fam Pract 2013;14:40.
2. Kim S, Love F, Quitsberg DA, Shea JA. Association of health literacy with diabetes outcomes. JAMA 2002;288:475-82.
3. Schillinger D, Grumbach K, Piette J, Wang F, Osmond D, Daher C, et al. Association of health literacy with self-management behavior in patients with diabetes. Diabetes Care 2004;27:2980-2.
4. Cavanaugh K, Wallston KA, Gebretsadik T, Shintani A, Huizinga MM, Davis D, et al. Addressing literacy and numeracy to improve diabetes care: Two randomized controlled trials. Diabetes Care 2009;32:2149-55.
5. Huizinga MM, Elsay TY, Wallston KA, Cavanaugh K, Davis D, Gregory RP, et al. Development and validation of the Diabetes Numeracy Test (DNT). BMC Health Serv Res 2008;8:96.
6. Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus – Present and future perspectives. Nat Rev Endocrinol 2012;8:228-36.
7. Williams MV, Parker RM, Baker DW, Parikh NS, Pitkin K, Coates WC, et al. Inadequate functional health literacy among patients at two public hospitals. JAMA. 1995;274:1677-82.
8. Sarkar U, Karter AJ, Liu JY, Moffet HH, Adler NE, Schillinger D. Hypoglycemia is more common among type 2 diabetes patients with limited health literacy: The Diabetes Study of Northern California (DISTANCE). J Gen Intern Med 2010;25:962-8.
9. Al Sayah F, Majumdar SR, Williams B, Robertson S, Johnson JA. Health literacy and health outcomes in diabetes: A systematic review. J Gen Intern Med 2013;28:444-52.
10. Bains SS, Egede LE. Associations between health literacy, diabetes knowledge, self-care behaviors, and glycemic control in a low income population with type 2 diabetes. Diabetes Technol Ther 2011;13:335-41.
11. Mancuso JM. Impact of health literacy and patient trust on glycemic control in an urban USA population. Nurs Health Sci 2010;12:94-104.
12. Tehrani Banihashemi A, Amirkhani M, Haghdoost AA, Alavian SM, Asgharifard H, Baradaran H, et al. Health literacy and the affecting factors: A study in five provinces of Iran. J Med Educ Dev Cent 2007;4:1-9.
13. Haghdoost AA, Rakhshani F, Aarabi M, Montazeri A, Tavousi M, Solimanian A, et al. Iranian health literacy questionnaire (IHLQ): An instrument for measuring health literacy in Iran. Iran Red Crescent Med J 2015;17:e25831.
14. Osborn CY, Cavanaugh KL, Wallston KA, White RO, Rothman RL. Diabetes numeracy: An overlooked factor in understanding racial disparities in glycemic control. Diabetes Care 2009;32:1614-9.
15. Baker DW, Williams MV, Parker RM, Gazmararian JA, Nurss J. Development of a brief test to measure functional health literacy. Patient Educ Couns 1999;38:33-42.
16. Mulvaney SA, Lilley JS, Cavanaugh KL, Pittel EJ, Rothman RL. Validation of the diabetes numeracy test with adolescents with type 1 diabetes. J Health Commun 2013;18:795-804.
17. Oguz A, Tuzun D, Ozdemir D, Baci Y, Ersoy R, Avsar AE, et al. Prevalence of gestational diabetes mellitus in patients with gestational thyroidotoxicosis. Gynecol Endocrinol 2013;29:336-9.
18. Brega AG, Jiang L, Beals J, Manson KJ, Roubideaux Y. Special Diabetes Program for Indians Healthy Heart Demonstration Project. Special diabetes program for Indians: Reliability and validity of brief measures of print literacy and numeracy. Ethn Dis 2012;22:207-14.
19. Bowen ME, Cavanaugh KL, Wolff K, Davis D, Gregory B, Rothman RL. Numeracy and dietary intake in patients with type 2 diabetes. Diabetes Educ 2013;39:40-7.
20. Ferguson MO, Long JA, Zhu J, Small DS, Lawson B, Glick HA, et al. Low health literacy predicts misperceptions of diabetes control in patients with persistently elevated A1C. Diabetes Educ 2015;41:309-19.
21. Mohammadi Z, Tehrani Banihashemi A, Asgharifard H, Bahramian M, Baradaran HR, Khamseh ME. Health literacy and its influencing factors in Iranian diabetic. Med J Islam Repub Iran 2015;29:230-0.
22. Chen P, Elmer SL, Calissaya M, Greenaway T, Wills KE, Buchbinder R, et al. Influence of Health Literacy on Foot Outcomes in Diabetes: A Systematic Review Protocol. In 7th International Symposium on the Diabetic Foot; 2015.