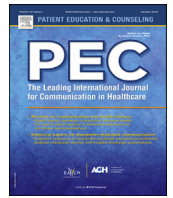




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Validation of a combined health literacy and numeracy instrument for patients with type 2 diabetes

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ABSTRACT

Objectives: This study aimed to validate a new consolidated measure of health literacy and numeracy (health literacy scale [HLS] plus the subjective numeracy scale [SNS]) in patients with type 2 diabetes (T2DM).

Methods: A convenience sample (N = 102) of patients with T2DM was recruited from an academic family medicine center in the southeastern US between September–December 2017. Participants completed a questionnaire that included the composite HLS/SNS (22 questions) and a commonly used objective measure of health literacy—S-TOFHLA (40 questions). Internal reliability of the HLS/SNS was assessed using Cronbach's alpha. Criterion and construct validity was assessed against the S-TOFHLA.

Results: The composite HLS/SNS had good internal reliability (Cronbach's alpha = 0.83). A confirmatory factor analysis revealed there were four factors in the new instrument. Model fit indices showed good model-data fit (RMSEA = 0.08). The Spearman's rank order correlation coefficient between the HLS/SNS and the S-TOFHLA was 0.45 ($p < 0.01$).

Conclusions: Our study suggests that the composite HLS/SNS is a reliable, valid instrument.

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1. Introduction

Health literacy is defined as “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” [1]. Health numeracy is defined as “the degree to which individuals have the capacity to access, process, interpret, communicate, and act on numerical, quantitative, graphical, bio-statistical, and probabilistic health information needed to make effective health decisions” [2]. Both low health literacy and low health numeracy have been associated with poor health outcomes [3–5]. Further, low levels of health literacy and numeracy are common among patients with diabetes and are associated with poor glycemic control, lower self-care activities, lower self-efficacy, and worse communication with healthcare providers [6–8].

The prevalence of diabetes has increased rapidly in the US [9]. In 2015, an estimated 30.3 million people, or 9.4% of the US population, had diabetes [9]. The serious health challenges facing

people with diabetes include heart disease, stroke, kidney disease, blindness, and foot amputation [10]. The total estimated cost of diagnosed diabetes in 2017 is \$327 billion, including \$237 billion for direct medical costs and \$90 billion for lost productivity [11]. Successful management of diabetes requires sufficient literacy and numeracy skills. Thus, the measurement of health literacy and numeracy is crucial to address these health challenges in this population.

Continuous efforts have been made to develop instruments of health literacy, both subjective and objective tests, including diabetes-specific measurement [12–14]. The Short Test of Functional Health Literacy in Adults (S-TOFHLA), a non-diabetes specific instrument, has been used in previous studies to measure health literacy in patients with diabetes [15]. However, limitations of the S-TOFHLA include limited assessment of numeracy and reading skills [12]. Other instruments have additional limitations, such as increased participant burden and the potential for discomfort and embarrassment from the objective measures [12]. For example, the Diabetes Numeracy Test (DNT) and the Wide Range Achievement Test (WRAT) both require a longer administration time [12]. Furthermore, patients prefer subjective tests and indicate they are more likely to take these tests, compared with the objective tests that require mathematical calculations or test content knowledge

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[16]. A suggestion was recently made [12,14] that a self-reported (subjective) health literacy measure should be used, such as the 3-level health literacy scale (HLS), originally developed in Japanese by Ishikawa, Takeuchi, and Yano to measure the functional, communicative and critical health literacy in people with diabetes [17], supplemented by health numeracy assessments, in patients with diabetes.

The HLS [17] and the 8-item Subjective Numeracy Scale (SNS-8) [16] are relatively easy to use: They can be self-administered and the time to complete them is comparatively short (6 min and 2 min, respectively) [12], thus they may be more suitable for clinical settings and research applications. However, to our knowledge, no research has been done to evaluate the combination of these previously independent measures as a composite measure of health literacy and numeracy in patients with type 2 diabetes (T2DM). The aim of this study was to validate this composite instrument of health literacy and numeracy, a combination of HLS and SNS-8 (HLS/SNS), among patients in a primary care setting.

2. Methods

2.1. Study design and sample

The study was conducted in an academic family medicine clinic, located in a region with high rates of poverty and large percentages of racial/ethnic minorities in the southeastern US. Patients with T2DM were enrolled between September–December 2017. The study was approved by the University Institutional Review Board. Graduate assistants invited patients to participate in the study right after their visits with their health care provider. Upon signing the informed consent form, a questionnaire was given to the patient to complete inside the clinic. A \$20 gift card was given to the patient at the end of the survey. Inclusion criteria for the study were: 1) Age 18 years or older; 2) A diagnosis of T2DM for at least 1 year; and 3) Able to complete informed consent.

2.2. Questionnaire and measurements

Subjective Tests of Health Literacy and Numeracy: The subjective tests included a combination of both the HLS [17] and SNS-8 [16]. The questionnaire was assessed and determined to be at a 6th grade reading level. The health literacy test is the HLS, which consists of 14 items covering three components—functional health literacy (5 items), communicative health literacy (5 items), and critical health literacy (4 items). Each item (question) is on a 4-point scale (i.e., “never”, coded as 1, “rarely”, as 2, “sometimes”, as 3, and “often”, as 4) [17]. The total HLS score was summed after reverse-coding the 5 items in the functional literacy section so that a higher score indicates higher levels of health literacy. The HLS yields a continuous score from 14 to 56.

The numeracy test—the SNS-8 [16]—consists of eight questions, each on a 6-point Likert response scale. This portion contains no mathematics questions and has no correct or incorrect answers. Instead, there are 4 questions asking respondents to assess their numerical ability in different contexts and 4 questions asking them to state their preferences for the presentation of numerical and probabilistic information. Thus, the SNS-8 measures perceptions of quantitative ability rather than the actual ability itself, a proxy for tests of objective numeracy. Four questions (i.e., “fractions”, “percentages”, “tip”, and “shirt”) measure perceived arithmetic abilities; another four questions (i.e., “newspaper”, “words”, “weather”, and “numerical useful”) measure preferences for use of numbers [16]. The scores were summed after reverse coding the “weather” question. Thus, a larger score indicates a higher subjective rating of numeracy abilities and preferences. The SNS-8 yields a continuous score from 8 to 48. Combined, the total

score of the composite HLS/SNS was the sum of HLS and SNS-8, ranging from 22 to 104.

Objective Measures of General Health Literacy and Numeracy: Our questionnaire included the S-TOFHLLA, which consists of two prose passages (a score from 0 to 36) and the four numeracy questions (a score from 0 to 4). The S-TOFHLLA yields a continuous score from 0 to 40 [18].

The following data were also collected in our questionnaire: age (years), sex, race (white, black/African American, Asia, American Indian/Alaskan Native, Native Hawaiian/other Pacific Islander, and other), highest educational attainment (less than high school, high school, or some college or above), annual household income (<\$15,000, \$15,000–<\$25,000, \$25,000–<\$35,000, \$35,000–<\$50,000, and >\$50,000), and age when T2DM diagnosis was first made. The duration of diabetes was calculated as current age minus the age at the time of diagnosis of T2DM.

2.3. Statistical analysis

The internal reliability of the composite HLS/SNS was tested using Cronbach's alpha. Confirmatory factor analysis (CFA) was applied to test construct validity. Concurrent validity was evaluated using Spearman's rank order correlation with the S-TOFHLLA. Criterion validity was assessed (ANOVA test) through comparison of the means of scores from the HLS/SNS in groups with different educational attainments (< high school, high school graduate, or some college or above). We also compared the distribution (e.g., variance and skewness) of the standardized scores of the two instruments—HLS/SNS and S-TOFHLLA. That is, we divided the raw scores from the HLS/SNS and S-TOFHLLA by their respective possible full scores of 104 and 40. Finally, we assessed the floor and ceiling effects [19] after rescaling the raw scores of S-TOFHLLA. Following prior research [20], the score in the reading comprehension section was scaled to give a score range of 0 to 72 (a total of 36 questions * 2 = 72) while the score in the numeracy section was scaled to give a range of 0–28 (a total of 4 questions * 7 = 28). Thus, the total rescaled score in S-TOFHLLA would range from 0 to 100. According to this score, we categorized patients into three groups of health literacy: inadequate (0–53), marginal (54–66), and adequate (67–100). Analyses were conducted using SAS 9.4 (Cary, NC: SAS Institute)

3. Results

3.1. Participants characteristics

A convenience sample (N = 102) of patients with T2DM was enrolled in the study. The study sample was diverse: 47% of patients were 50–64 years of age (average age 60 years, standard deviation = 10.9, range = 28–79 years); 73% were females; 73% were African American, 23% White; 44% reported ≤ high school education; and 61% reported an annual household income less than \$35,000 (Table 1). No significant differences were found in mean scores of health literacy and numeracy by HLS/SNS by different groups of age, race, and sex (Data not shown in table).

3.2. Internal reliability

The composite HLS/SNS and the individual components—HLS and SNS-8, all had good internal reliability, with Cronbach's alphas of 0.840, 0.782, and 0.834, respectively (Data not shown in table), which are greater than 0.7, indicating satisfactory reliability [21].

3.3. Construct validity

A CFA revealed that there were four factors in the new instrument, consistent with the 3 components in the HLS—functional literacy,

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