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Differential Relationships between Diabetes Knowledge Scales and Diabetes Outcomes

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Abstract

Background: Diabetes affects more than 29 million people in the US and requires daily self-management in addition to knowledge of the disease. Three knowledge assessments used are the Michigan Brief Diabetes Knowledge Test (DKT), Starr County Knowledge Questionnaire (DKQ), and the Kaiser DISTANCE Survey.

Purpose: The purpose of the study was to test the discriminate validity of three diabetes knowledge scales and determine which is best associated with diabetes self-care and glycemic control.

Methods: Three hundred sixty-one adults with type 2 diabetes were recruited from primary care clinics. Four analyses were conducted to investigate the validity and relationships of the scale: alpha statistic to test internal validity, factor analysis to determine how much of the variance was explained, Pearson's correlation between the three scales, and Pearson's correlation between each scale, self-care, and outcomes.

Results: The DKQ had an alpha of 0.75; the DKT had an alpha of 0.49; and the DISTANCE had an alpha of 0.36. The DKQ was significantly correlated with glycemic control. The DKT scale was significantly associated with general diet, the DISTANCE survey was significantly associated with exercise, and both DKT and DISTANCE were significantly associated with foot care.

Conclusion: Correlations among the three scales were modest, suggesting the scales are not measuring the same underlying construct. These findings indicate that researchers should carefully select scales appropriate for study goals, or to appropriately capture the information being sought to inform practice.

Keywords

Diabetes; Knowledge; Glycemic Control; Self-care

Introduction

About 29.1 million people in the United States (US) had diabetes in 2012 and total costs of the disease were \$245 billion (1). Diabetes is the 7th leading cause of death in the US, leading to more than 1.5 million deaths, over twice the number of deaths from diabetes in 1990 (1-3). In fact, globally, the number of people with diabetes has risen from 108 million in 1980 to 422 million in 2014, surpassing global estimates of 328 million cases worldwide expected by 2030 (2,4). The increase in cases and deaths illustrates the gravity of this disease. Diabetes is a growing epidemic that has serious effects on physical and emotional well-being of those with the disease, and on the economy (1). Participation in diabetes self-management education and support (DSME & DSMS) has been shown to significantly reduce hemoglobin A1c (A1C), a measure of glycemic control, which decreases risk of mortality and complications (5,6). DSME is a hallmark of quality diabetes care and involves the process of gaining knowledge and skills necessary for diabetes self-care activities (6,7).

Chronic disease knowledge, specifically about diabetes is key in understanding how the disease works and how applying the information to self-care practices can improve overall outcomes (8,9). Increasing diabetes knowledge is associated with improvements in outcomes such as A1C level and medication adherence (6,8,10-13). Interventions that focus on increasing diabetes self-management and knowledge have improved both the physical and mental components of quality of life, and decreased A1C (14,15). Increases in diabetes knowledge have also been associated with decreased fasting glucose, and cholesterol (16-19). Specific aspects of diabetes knowledge have been shown to improve self-care, for example, those with more knowledge of the definition of A1C and their most recent value are more likely to have better diet and reported higher levels of self-efficacy for physical activity (20). Education is expected to help improve self-care knowledge, health skills, and patients' self-efficacy enabling the patient to better take care of the disease and improve outcomes (18,21).

A variety of assessments are used in the US to capture diabetes knowledge in patients with diabetes. Knowledge assessments can measure different components of knowledge, and/or focus on specific topics that are shown to be important in maintaining good glycemic control. Three used commonly in the US are: Starr County Diabetes Knowledge Questionnaire (DKQ), Michigan Diabetes Knowledge Test (DKT), and the DISTANCE Survey (DISTANCE) (22-24). The DKQ is a 24-item questionnaire that started out as a 60-item questionnaire administered among English and Spanish – speaking Mexican American patients with type 2 diabetes in Starr County, Texas (25). The original DKQ was shortened to include 24-items and has been shown to be valid and reliable (22). This assessment has been used to show that diabetes knowledge is significantly associated with glycemic control (26). The DKT consists of 23-items, where the first 14 items are general diabetes knowledge questions and the last 9 are specific to insulin use; both components of this scale have been found to be reliable and valid (23). Studies have found that DKT knowledge scores were lower in patients with diabetes who had shorter disease duration, fewer complications, shorter duration of insulin usage, and less home blood glucose monitoring (27). Level of education, family income, presence of complications are shown to be significant determinants of knowledge using the DKT scale (16,27). A1C was found to be negatively

correlated with diabetes knowledge using the DKT (16). The diabetes knowledge component of the DISTANCE survey is made up of 5-items (24). This scale has not been used as often as the DKQ or DKT in studies, but is attractive based on the short length.

Given little work has been done to compare the multiple scales available to measure diabetes knowledge, the aim of this study was to test the discriminate validity of three diabetes knowledge scales and to determine which scale is best associated with diabetes self-care practices and glycemic control.

METHODS:

Research design and sample

Three hundred sixty-one participants from an academic medical center general internal medicine clinic and a Veterans Affairs primary care clinic were recruited for this study. Eligible patients were required to be adults (18 years or older) and be diagnosed with type 2 diabetes. Exclusion criteria included not being able to speak English, or cognitive impairment that precluded valid responses to questions. All procedures were approved by the local Institutional Review Board and Veterans Administration Research and Development Committee prior to patient contact.

Data Collection

Patients in the waiting rooms at the two clinics were approached and informed of the study. Those who were interested were taken to a private area to complete a self-administered survey, which included the three knowledge scales, a previously validated self-care scale, and a previously validated medication adherence scale. Patients completed the survey independently, unless they requested assistance in reading the questions or responses. Responses were checked to confirm patients answered all questions, and then entered into a database for statistical analysis. Afterwards, lab results were abstracted from their medical record and entered into the database.

Variables

The main variable of interest was diabetes knowledge as measured by three scales. The first scale was the 24-item Diabetes Knowledge Questionnaire (DKQ) (22). The DKQ has a reliability coefficient of 0.78 and showed sensitivity to a diabetes knowledge intervention. Questions were selected during creation to target knowledge deficits which can be related to measurable outcomes, false statements, or those known to be common and/or serious misconceptions. Answer choices for the questions include, “yes”, “no”, and “I don’t Know”. The final score is a percentage of correct answers. The second scale was the 23-item Diabetes Knowledge Test (DKT) (23). The DKT consists of a 14-item general test and a 9-item insulin-use subscale. The DKT has a reliability coefficient of an average of 0.71 for the general test and an average of 0.75 for the insulin-use subscale. Both components of the DKT are reliable and have a reliability coefficient 0.70. The DKT was found to be reliable and valid in both the tested community and health department samples. The DKT provides 4 choices for responses to the questions asked and is at the 6th grade reading level. The third

scale that was used was the 5-item diabetes knowledge assessment found in the Northern California DISTANCE Survey (DISTANCE) (24).

Self-Reported Medication Adherence was assessed with the 8-item self-report Morisky Medication Adherence Scale (MMAS) (28,29). Each of 8 items measures a specific medication-taking behavior. The scale has higher reliability compared with the older 4-item scale ($\alpha = 0.83$ vs. $\alpha = 0.61$).

Behavioral Skills were assessed using the Summary of Diabetes Self-Care Activities (SDSCA) scale (30). This is an 11-item, validated self-report questionnaire of diabetes self-management that assesses the frequency of self-care activities, including diet, exercise, medication adherence, foot care, and self-blood glucose testing in the past 7 days. The average inter-item correlations within scales are high; test-retest correlations are moderate; and correlations with other measures of diet and exercise generally support the validity of the SDSCA subscales.

Biologic measures included A1C collected in the past 6 months, blood pressure collected in the past 6 months, and lipids collected in the past 12 months. Lab values that fell outside the time frame were not used.

Demographic variables were also assessed using previously validated scales. (31)

Statistical Analysis

To investigate the validity and relationships between each knowledge scale and diabetes outcomes, four sets of analyses were completed. First, an alpha statistic was run on each scale to test internal validity. Second, factor analysis was completed on each scale to determine the amount of variance explained by a single factor. Third, Pearson's correlations were run between the three scales. And finally, Pearson's correlations were run between each scale, the self-care subscales, medication adherence, and the three biologic measures. All analyses were completed using Stata version 14 software.

Results

Sample Demographics

The demographic makeup of this sample is shown in Table 1. Eleven percent were between 18 – 49 years, 43% were between 50 – 64 years, 29% were between 65 – 74 years, and 17% were between 75 – 89 years of age. The mean age of the sample was 63 years; the mean duration of time with diabetes was 13 years, and the mean number of hours worked per week and comorbidities were 8 and 5 respectively. The majority were men (66%), married (47%), and non-Hispanic Black (NHB) (60%). The majority of the sample completed college (40%), earned less than \$10,000 (19%), and had VA medical insurance (41%). 69% of the patients had more than 3 comorbidities, 47% never smoked, and 57% participated in moderate – vigorous activity less than 3 days per week.

Psychometrics of Knowledge Scales

The 24-item DKQ by Garcia had an alpha of 0.75 with one factor explaining 15% of the variance. The 23-item Michigan DKT had an alpha of 0.49 with one factor explaining 10% of the variance. The 5-item DISTANCE knowledge assessment had an alpha of 0.36 with one factor explaining 28% of the variance.

Correlation

Table 2 shows the correlation between diabetes knowledge tests. The DKQ and DKT had a significant moderate pairwise correlation of 0.47 ($P<0.0001$). The DKQ also had a significant moderate pairwise correlation of 0.41 ($P<0.0001$) with the DISTANCE assessment. The DKT had a significant moderate pairwise correlation with the DISTANCE assessment of 0.56 ($P<0.0001$).

Table 3 shows the correlation between diabetes knowledge tests, outcomes, and self-care practices. Only the DKQ had a statistically significant correlation with A1C of 0.12 ($P=0.03$). The DKT was the only assessment that had a significant correlation with general diet, 0.15 ($P=0.004$). The DISTANCE survey had a significant correlation of 0.14 ($P=0.01$) with exercise. Foot care had a significant negative correlation with both the DKT, -0.15 ($P=0.004$), and the DISTANCE surveys, -0.13 ($P=0.01$).

Discussion

By investigating three separate diabetes knowledge scales, this study found that the DKT, DKQ, and DISTANCE surveys had varying degrees of internal validity, and differential relationships with diabetes outcomes and health behaviors, at least in the analyzed sample. Based on these results, researchers and clinicians should carefully select scales depending on the purpose for which they are using results. Clinicians or diabetes educators who wish to assess a patients' diabetes knowledge should consider not only the length of the survey, but the constructs that will be measured based on the types of questions included.

The study found that the DKQ had the highest internal validity of the three knowledge scales that were investigated as measured by alpha. Internal validity or internal consistence is a description of the degree to which all items in the test measure the same concept, in this case diabetes knowledge (32). Lower alpha values for the DKT and DISTANCE tests suggest that while the tests are measures of diabetes knowledge, items within each of the test may be measuring varying types of knowledge or multiple constructs. For example, three of the five questions included in the DISTANCE survey asks the patient to select from a list of 4 different foods which is the highest in carbohydrates, which is highest in fat, and which provides low fat protein. Questions such as these may be more indicative of the patient's knowledge of nutrition or diet rather than their overall diabetes knowledge. The last two questions in the DISTANCE survey are, "hemoglobin A1c is a test that is a measure of a person's average blood glucose for the past:"; and "if a person with diabetes suddenly gets sweaty, nervous, and shaky, what should he or she do?" These questions are more specific to diabetes management, which may be a separate, though related construct to nutrition. Because the DISTANCE survey was the shortest of the three surveys examined, the breadth

of information gathered may not be comprehensive enough to explain the overarching construct of diabetes knowledge. This may explain why the DISTANCE survey had the lowest alpha. On the other hand, the DKQ included questions requiring an understanding of how diabetes affects the body, and how to prevent complications. There are only two items in the DKQ that test knowledge specific to nutrition/diet. Given the high internal validity of the DKQ, and the fact it was the only scale in this study correlated to A1C, results suggest that a comprehensive view of knowledge, rather than a narrow view is better correlated with glycemic control.

In addition to differences in internal validity, the study found that correlation among the three scales were only modest, again suggesting the scales may not be measuring the same construct. Correlation coefficients are used to describe the strength and direction of a relationship between two scales (33). Whenever two or more tests are assumed to measure the same construct then a correlation analysis between the tests is conducted (34). These results indicate that the three scales, DKQ, DKT, and DISTANCE, should not be used interchangeably nor be expected to provide consistent information regarding a patient's diabetes knowledge if the same scale is not used for repeated measures. Researchers should be aware that though the three scales are measuring diabetes knowledge overall, they are not measuring the same construct of knowledge, nor are assessing knowledge in the same manner. As such, they should make an a priori decision regarding the information they wish to gain from their patients and then choose a scale to use that will accurately answer their question. The findings indicate that researchers should carefully select scales to be used depending on the study goals, and that clinicians should also be careful to select appropriate scales to assess knowledge when using that information to inform practice.

This study has three limitations that should be mentioned. First, this was a cross-sectional study design, limiting our ability to examine changes in knowledge, outcomes, and self-care behaviors overtime. Secondly, this study was conducted in the southeastern region of the United States and results may not be generalizable to populations in other areas of the nation or world. Finally, due to the breadth of diabetes knowledge assessments currently available, the researchers only included three to maintain appropriate length and feasibility of completing the surveys by study participants. However, these are the three most commonly used scales to measure diabetes knowledge in the United States.

Conclusions

In conclusion, this study found that while three commonly used diabetes knowledge tests (DKQ, DKT, DISTANCE) are valid and reliable, correlations between the tests are moderate, and the DKQ was the only assessment found to have a significant correlation between diabetes knowledge and glycemic control. Diabetes knowledge as measured by the DISTANCE and DKT was found to be significantly correlated with some elements of diabetes self-care activities. This study highlights the importance of carefully examining and selecting diabetes knowledge assessment tools that will measure the knowledge construct in a way that aligns with study goals or in the case of clinicians, in ways that appropriately capture the information being sought to inform practice.

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Table 1:

Sample Characteristics

n=361	Percentages (%)
Site	
MUSC	50.97
VAMC	49.03
Sex	
Male	66.20
Female	33.80
Age	
18 - 49	10.61
50 - 64	43.02
65 - 74	29.05
75 - 89	17.32
Marital Status	
Never Married	13.06
Married	47.22
Separated	8.33
Divorced	18.06
Widowed	13.33
Race	
H/Asian/AI	3.31
NHW	36.74
NHB	59.94
Education	
<High School	15.79
High School	33.24
College	40.44
Grad Education	10.53
Annual Income	
\$0 - \$9,999	18.84
\$10,000 - \$14,999	13.57
\$15,000 - \$19,999	11.63
\$20,000 - \$24,999	9.70
\$25,000 - \$34,999	14.96
\$35,000 - \$49,999	10.25
\$50,000 - \$74,999	9.42
> \$75,000	11.63
Insurance	
None	3.59
Private	10.50
Medicare	16.85

n=361	Percentages (%)
Medicaid	17.68
VA	40.61
Other	10.77
Comorbidity Categories	
0 - 1	5.25
2 - 3	25.69
4 - 5	34.53
6 - 11	34.53
Smoking	
Never	47.24
Former	37.57
Current	15.19
Mod/Vig Activity Weekly	
<3 days/week	57.34
> 3days/week	42.66

MUSC = Medical University of South Carolina

VAMC = Ralph H. Johnson Veterans Affairs Medical Center

All numbers represent percentages.

Table 2.

Pairwise correlation between knowledge scales

	DKQ	DKT	DISTANCE
DKQ	---	---	---
DKT	0.47 ***	---	---
DISTANCE	0.41 ***	0.56 ***	---

⁺ $P < 0.05$ * $P < 0.01$ ** $P < 0.001$ *** $P < 0.0001$

DKQ = Starr County Diabetes Knowledge Questionnaire

DKT = Michigan Diabetes Knowledge Test

DISTANCE = The Diabetes Study of Northern California Survey

Table 3.

Correlation between knowledge scales and outcomes

	A1c	Blood pressure	Lipids	General Diet	Exercise	Foot Care
DKQ	0.12 ⁺ p=0.03	---	---	---	---	---
DKT	---	---	---	0.15 [*] p=0.004	---	-0.15 [*] p=0.004
DISTANCE	---	---	---	---	0.14 ⁺ p=0.01	-0.13 ⁺ p=0.01

⁺ $P < 0.05$ ^{*} $P < 0.01$

DKQ = Starr County Diabetes Knowledge Questionnaire

DKT = Michigan Diabetes Knowledge Test

DISTANCE = The Diabetes Study of Northern California Survey