The Reliability and Validity of a Brief Diabetes Knowledge Test

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OBJECTIVE — To examine the reliability and validity of a brief diabetes knowledge test. The diabetes knowledge test has two components: a 14-item general test and a 9-item insulin-use subscale.

RESEARCH DESIGN AND METHODS — Two populations completed the test. In one population, patients received diabetes care in their community from a variety of providers, while the other population received care from local health departments. Cronbach's coefficient α was used to calculate scale reliability for each sample. To determine validity, patient group differences were examined. It was hypothesized that test scores would be higher for patients with type 1 diabetes, for patients with more education, and for patients who had received diabetes education.

RESULTS — The coefficient αs for the general test and the insulin-use subscale indicate that both are reliable, $\alpha \geq 0.70$. In the community sample, patients with type 1 diabetes scored higher than patients with type 2 diabetes on the general test and the insulin-use subscale. In the health department sample, patients with type 1 scored higher than patients with type 2 on the insulin-use subscale. For both samples, scores increased as the years of formal education completed increased, and patients who received diabetes education scored higher than patients who did not.

CONCLUSIONS — Although the samples differed demographically, the reliability and validity of the test were supported in both the community and the health department samples. This suggests that the test is appropriate for a variety of settings and patient populations.

For many years, the assessment of diabetes-related knowledge has been an important component in the overall assessment of patients with diabetes. Knowledge tests have been used in evaluation and research to measure knowledge as outcomes in diabetes patient education programs (1–5). Nevertheless, valid, reliable, and easy-to-use knowledge assessment instruments are scarce. To address this need, the Michigan Diabetes Research and Training Center (MDRTC) began a project in the mid-1980s to develop a series of valid and reliable knowledge tests that could be used by diabetes educators and researchers throughout the country.

The MDRTC test development process began by recruiting a nationally representative group of experts. This included diabetologists, dietitians, nurses, educational specialists, and psychologists who were recognized experts in diabetes. This expert panel was responsible for identifying the content domains to be tested and for developing test items. Test content areas were defined using a Delphi-type decision-making process with mailed questionnaires. Test items were developed during a 1-day consensus conference for tests specific for type 1, type 2 using insulin, and type 2 not using insulin. The test items were then distributed for review, editing, and additions by the expert panel. Item revision in accordance with the review was done by MDRTC staff members.

Various pilot tests were completed, and test items were analyzed to determine which items to retain, revise, or replace. Items needing revision or replacement were refined or developed by MDRTC staff. Factor and cluster analyses were used to examine the structure of response patterns for different patient populations. The evaluation of the tests continued for several years, and based on the results the tests eventually evolved into a single test in 1990. On the basis of an additional item analyses, the number of test items was reduced to the current total.

Current test form

The current diabetes knowledge test includes 23 items (see APPENDIX). The general test segment of the test has 14 items and is appropriate for adults with type 1 and type 2 diabetes. An additional nine items constitute the insulin-use subscale that is appropriate for adults with type 1 diabetes and type 2 patients using insulin. The 23-item test takes ~15 min to complete. The test's readability was measured by the Flesch-Kincaid grade level, and the reading level for the test items is at the 6th grade level.

To establish the diabetes knowledge test's utility, two research questions are addressed in this study: *1*) is the diabetes knowledge test reliable (both the general test and the insulin-use subscale)? and 2) is the diabetes knowledge test valid (both the general test and the insulin-use subscale)?

RESEARCH DESIGN AND METHODS

— To estimate the reliability and validity of the diabetes knowledge test, test results from two separate populations were examined. In one population, patients received diabetes care in their community from a variety of local health care providers and plans, while the other population received diabetes care from a local health department.

Hypotheses

Four hypotheses were tested in the two samples. *1*) The general test score and the insulin-use subscale score are reliable (i.e., the responses to the individual scale items

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Received for publication 7 October 1997 and accepted in revised form 23 January 1998.
Abbreviations: MDRTC, Michigan Diabetes Research and Training Center.

Table 1—*Diabetes knowledge test validation hypotheses: summary table*

Expected score differences	General test (items 1–14)		Insulin use (items 15–23)	
	Community	MDPH	Community	MDPH
Diabetes type differences				
Type 1 > type 2	✓		✓	✓
Educational levels				
Higher > lower	✓	✓	✓	✓
Diabetes education received*				
Yes > no	✓	✓	✓	✓

*Participants were asked "Have you ever received diabetes education?" MDPH, Michigan Department of Public Health.

are internally consistent). 2) The general test score and the insulin-use subscale score will differ by diabetes type; patients with type 1 diabetes will score higher than patients with type 2 diabetes (Table 1). 3) The general test score and the insulin-use subscale score will differ by educational level; patients with more education will have higher scores (Table 1). 4) The general test score and the insulin-use subscale score will differ by diabetes education received; patients who received diabetes education will score higher than patients who have not received diabetes education (Table 1). If the test is a valid measure, it is hypothesized that patients with type 1 diabetes will score higher than patients with type 2 diabetes. This expectation is based on the facts that type 1 diabetes is more severe (untreated it is immediately life threatening) and its treatment more complex. Further, this relationship was found in a MDRTC study that examined the psychometric characteristics of an earlier diabetes patient knowledge test (6).

Patients

The community sample was drawn from four Michigan communities; two large and two small. Participants were self-selected, responding to either a newspaper advertisement or posters displayed in waiting rooms to participate in a diabetes evaluation and education project. Patients were also referred to the project by local diabetes educators who led diabetes support groups. Eligibility criteria required that participants have diabetes and be at least 18 years old.

The health department sample consisted of patients admitted into the County Health Department Diabetes Program sponsored by the Michigan Department of Public Health. Individuals eligible for health care from county health departments usually have limited financial resources and inadequate access to other health services. To participate in this program, patients responded to an advertisement campaign or were referred to the program by a physician. Eligibility criteria required that participants have diabetes and reside within the county where the health department was located. There was no age restriction. Four health departments participated in the study.

For evaluation of the diabetes knowledge test, health department patients under the age of 18 (n = 10) were omitted. Furthermore, 16 patients from the health department sample were dropped because of a large number of no responses (13 had not answered a single test question and 3 had answered two or less).

Patients completed the diabetes knowledge test during a nurse visit at their home (community sample) or before a scheduled health care visit (health department sample). The demographics of the community sample and the health department sample were examined to determine if and how the two samples differed. Patient age and years since diabetes diagnosis differences were determined by t tests. χ^2 analyses were used to determine differences in sex, ethnicity, diabetes type, and treatment, education level, and diabetes education received.

Cronbach's coefficient α (7) was used to calculate scale reliability. Reliabilities were calculated for each sample and overall (the samples combined).

Each sample was examined separately for validation testing. General test scores were examined by diabetes type and treatment using analysis of variance (with a Bonferroni adjustment for multiple statistical tests, $P = 0.01$). Differences among the three categories were determined by the Tukey-Kramer honestly significant difference test (global $P = 0.05$). Insulin-use subscale score differences between patients with type 1 diabetes and patients with type 2 diabetes using insulin was determined by a t test (with a Bonferroni adjustment for multiple statistical tests, $P = 0.01$).

General test and the insulin-use subscale scores were examined by educational

Table 2—*Demographic characteristics*

	Community	MDPH	*P* value
n	312	499	
Women (%)	58	68	<0.01
Age	60 ± 14 (22–88)	56 ± 14 (20–94)	<0.01
Ethnic origin (%)			
Caucasian	89	70	<0.01
African-American	7	17	
Other	4	13	
Diabetes type and treatment (%)			
Type 1	8	9	0.62
Type 2 using insulin	28	30	
Type 2 not using insulin	64	61	
Years since diagnosis	10 ± 10 (<1–52)	9 ± 8 (<1–47)	0.10
Has received diabetes education (%)	61	52	0.01
Years of formal education completed (%)			
8 or less	10	12	0.34
9–11	12	17	
12	39	35	
13–15	26	24	
16 or more	13	12	

Data for age and years since diagnosis are means ± SD (range).

Table 3—*Test reliabilities*

Component*	Community		MDPH		Total	
	Percent correct	Item-total correlation	Percent correct	Item-total correlation	Percent correct	Item-total correlation
General test (items 1–14)						
n	312		499		811	
1	87	0.19	82	0.23	84	0.22
2	42	0.38	46	0.32	45	0.34
3	36	0.16	29	0.26	32	0.23
4	61	0.29	53	0.38	56	0.35
5	29	0.27	28	0.18	29	0.22
6	79	0.25	72	0.28	74	0.27
7	59	0.36	51	0.35	54	0.36
8	54	0.42	52	0.38	53	0.39
9	90	0.28	81	0.30	85	0.30
10	78	0.28	80	0.29	79	0.28
11	88	0.40	88	0.33	88	0.35
12	88	0.30	84	0.40	85	0.37
13	81	0.41	75	0.43	77	0.43
14	93	0.38	90	0.37	91	0.37
Insulin use (items 15–23)						
n	111		195		306	
15	16	0.35	20	0.34	19	0.33
16	86	0.36	74	0.41	78	0.40
17	47	0.36	34	0.44	39	0.42
18	55	0.51	59	0.24	58	0.33
19	90	0.21	79	0.36	83	0.32
20	74	0.52	70	0.53	71	0.53
21	60	0.49	67	0.53	64	0.51
22	79	0.48	65	0.55	70	0.53
23	43	0.45	35	0.50	38	0.49

Cronbach's coefficient α for the general test for the community, MDPH, and total was 0.70, 0.71, and 0.71, respectively, and for insulin use was 0.74, 0.76, and 0.75, respectively. *Missing items are scored as incorrect. MDPH, Michigan Department of Public Health.

level using analysis of variance (with a Bonferroni adjustment for multiple statistical tests, $P = 0.01$). Differences were determined by the Tukey-Kramer honestly significant difference test (global $P = 0.05$).

Differences in the general test and insulin-use subscale scores by diabetes education received were examined using *t* tests (with a Bonferroni adjustment for multiple statistical tests, $P = 0.01$).

RESULTS — Demographic differences were found between the two samples (Table 2). The health department sample had a higher percentage of women, were younger on average, had fewer Caucasians, and were less likely to have received diabetes education. No significant differences were found between the two samples for diabetes type and treatment, years since diagnosis, and education completed.

Reliability

The coefficient α values for the general test and the insulin-use subscale indicate that both are reliable, ($\alpha \geq 0.70$) (Table 3). The reliability estimates for the two samples were similar.

Validity tests

Scores by diabetes type and treatment. In the community sample, patients with type 1 diabetes scored higher than patients with type 2 diabetes on the general test and on the insulin-use subscale (Table 4). In the health department sample, patients with type 1 diabetes scored higher than patients with type 2 diabetes on the insulin-use subscale (Table 4).

Scores by educational level. General test and insulin-use subscale scores by educational level are provided in Table 5. For each sample, scores increase as the years of formal education completed increase.

Scores by diabetes education received. For both samples, patients who received diabetes education scored higher than patients who did not receive diabetes education (Table 6). The scores were higher for both the general test and the insulin-use subscale.

CONCLUSIONS — The reliability and validity of the diabetes knowledge test were supported in both the community and the health department samples. The only hypothesis that was not realized was a difference in the general test scores by diabetes types for the health department sample. Although patients with type 1 diabetes did score higher than patients with type 2 diabetes, the difference was not statistically significant. Nevertheless, this suggests that the test is appropriate for a variety of settings and patient populations. The latter is supported by the fact that although the samples differed demographically, the

Table 4—*Test scores and diabetes types*

Diabetes type and treatment	General test % correct (items 1–14)	Insulin use % correct (items 15–23)
Community sample		
Type 1	88.57 ± 9.89 (25)	82.67 ± 16.38 (25)
Type 2 using insulin	68.27 ± 17.86 (86)	55.04 ± 23.49 (86)
Type 2 not using insulin	66.54 ± 18.08 (200)	—
Difference	$P < 0.0001$	$P < 0.0001$
MDPH sample		
Type 1	72.26 ± 20.51 (43)	75.93 ± 22.88 (42)
Type 2 using insulin	64.00 ± 18.40 (152)	52.23 ± 23.21 (147)
Type 2 not using insulin	64.76 ± 19.87 (304)	—
Difference	$P = 0.04$	$P < 0.0001$

Data are means ± SD (*n*). MDPH, Michigan Department of Public Health.

Table 5—*Test scores and educational level*

Type and education level	General test % correct (items 1–14)	Insulin use % correct (items 15–23)
Community sample		
8 years or less	54.02 ± 22.07 (32)	44.44 ± 25.20 (8)
9–11 years	60.34 ± 17.79 (38)	45.10 ± 20.59 (17)
12 years	68.36 ± 16.59 (121)	60.98 ± 23.30 (43)
13–15 years	77.23 ± 16.00 (80)	70.00 ± 25.13 (30)
≥16 years	74.11 ± 15.15 (40)	73.50 ± 20.05 (13)
Difference	$P < 0.0001$	$P = 0.0009$
MDPH sample		
8 years or less	52.09 ± 17.39 (58)	47.74 ± 21.09 (27)
9–11 years	56.55 ± 17.74 (85)	43.84 ± 19.94 (37)
12 years	64.98 ± 19.16 (176)	56.73 ± 25.27 (66)
13–15 years	71.37 ± 16.97 (121)	72.61 ± 23.43 (43)
≥16 years	78.82 ± 17.28 (57)	68.06 ± 21.42 (16)
Difference	$P < 0.0001$	$P < 0.0001$

Data are means ± SD (*n*). MDPH, Michigan Department of Public Health.

test characteristics remained constant.

The diabetes knowledge test is also a short test (14 or 23 items depending on whether the patient is using insulin). As such, it can be administered quickly to patients and easily interpreted by a health professional. The fact that the diabetes knowledge test is a single test is both a strength and a weakness. A single test allows users to make comparisons among different patient groups. However, as a single test it has a general focus and is not equally sensitive to the many aspects or components of diabetes education and care.

As with all assessment instruments, the usefulness and appropriateness of the diabetes knowledge test depends on the objectives of the health provider or the researcher. The diabetes knowledge test is an effective, efficient, and inexpensive way for a health professional to obtain a general assessment of a patient's knowledge about diabetes and its care. Because the test is short and the reading level is at the 6th grade level, the diabetes knowledge test can usually be self-administered. Review of correct and incorrect items also can be used to provide feedback to patients about areas where additional information is needed and creates opportunities for teachable moments. However, if a clinician wishes to comprehensively assess specific components of diabetes knowledge or self-care behaviors, this test may not be suitable, although a few situational items are included. The test is also appropriate as a measure of general diabetes knowledge levels for researchers. It can be a useful method for group comparisons and for assessing knowledge over time. This test's usefulness as an outcome measure for educational interventions remains to be determined.

Finally, although knowledge is not a good predictor of patient behavior, it is a prerequisite for a patient to perform appropriate self-care. The diabetes knowledge test is a valid and reliable measure for estimating patients general understanding of diabetes.

Table 6—*Test scores and diabetes education*

Received diabetes education	General test % correct (items 1–14)	Insulin use % correct (items 15–23)
Community sample		
Yes	73.26 ± 17.44 (191)	64.99 ± 24.01 (86)
No	61.92 ± 17.94 (121)	48.44 ± 23.98 (25)
Difference	$P < 0.0001$	$P = 0.003$
MDPH sample		
Yes	70.00 ± 18.83 (255)	60.93 ± 26.13 (126)
No	60.07 ± 19.10 (237)	50.00 ± 21.08 (62)
Difference	$P < 0.0001$	$P = 0.005$

Data are means ± SD (*n*). MDPH, Michigan Department of Public Health.

Acknowledgments— This study was supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health (5P60DK-20572) and the Michigan Department of Public Health.

We would like to recognize the efforts of Nancy Palchack, PhD, in the development and evolution of this instrument. We would also like to acknowledge the following individuals' participation in the study: John Floyd, MD; Carelyn Fylling, RN, MS; Margaret Powers, RD, MS; Donald Smith, MD; Susan Teza, RN; Fred Whitehouse, MD; and Judith Wylie-Rosett, EdD, RD.

APPENDIX: MDRTC DIABETES KNOWLEDGE TEST

1. The diabetes diet is:
   a. the way most American people eat
   b. a healthy diet for most people*
   c. too high in carbohydrate for most people
   d. too high in protein for most people
2. Which of the following is highest in carbohydrate?
   a. Baked chicken
   b. Swiss cheese
   c. Baked potato*
   d. Peanut butter
3. Which of the following is highest in fat?
   a. Low fat milk*
   b. Orange juice
   c. Corn
   d. Honey
4. Which of the following is a "free food"?
   a. Any unsweetened food
   b. Any dietetic food
   c. Any food that says "sugar free" on the label
   d. Any food that has less than 20 calories per serving*
5. Glycosylated hemoglobin (hemoglobin A1) is a test that is a measure of your average blood glucose level for the past:
   a. day
   b. week
   c. 6–10 weeks*
   d. 6 months
6. Which is the best method for testing blood glucose?
   a. Urine testing
   b. Blood testing*

c. Both are equally good
7. What effect does unsweetened fruit juice have on blood glucose?
   a. Lowers it
   b. Raises it*
   c. Has no effect
8. Which should not be used to treat low blood glucose?
   a. 3 hard candies
   b. 1/2 cup orange juice
   c. 1 cup diet soft drink*
   d. 1 cup skim milk
9. For a person in good control, what effect does exercise have on blood glucose?
   a. Lowers it*
   b. Raises it
   c. Has no effect
10. Infection is likely to cause:
   a. an increase in blood glucose*
   b. a decrease in blood glucose
   c. no change in blood glucose
11. The best way to take care of your feet is to:
   a. look at and wash them each day*
   b. massage them with alcohol each day
   c. soak them for one hour each day
   d. buy shoes a size larger than usual
12. Eating foods lower in fat decreases your risk for:
   a. nerve disease
   b. kidney disease
   c. heart disease*
   d. eye disease
13. Numbness and tingling may be symptoms of:
   a. kidney disease
   b. nerve disease*
   c. eye disease
   d. liver disease
14. Which of the following is usually not associated with diabetes:
   a. vision problems
   b. kidney problems
   c. nerve problems
   d. lung problems*
15. Signs of ketoacidosis include:
   a. shakiness
   b. sweating
   c. vomiting*
   d. low blood glucose
16. If you are sick with the flu, which of the following changes should you make?
   a. Take less insulin
   b. Drink less liquids
   c. Eat more proteins
   d. Test for glucose and ketones more often*
17. If you have taken intermediate-acting insulin (NPH or Lente), you are most likely to have an insulin reaction in:
   a. 1–3 h
   b. 6–12 h*
   c. 12–15 h
   d. more than 15 h
18. You realize just before lunch time that you forgot to take your insulin before breakfast. What should you do now?
   a. Skip lunch to lower your blood glucose
   b. Take the insulin that you usually take at breakfast
   c. Take twice as much insulin as you usually take at breakfast
   d. Check your blood glucose level to decide how much insulin to take*
19. If you are beginning to have an insulin reaction, you should:
   a. exercise
   b. lie down and rest
   c. drink some juice*
   d. take regular insulin
20. Low blood glucose may be caused by:
   a. too much insulin*
   b. too little insulin
   c. too much food
   d. too little exercise
21. If you take your morning insulin but skip breakfast your blood glucose level will usually:
   a. increase
   b. decrease*
   c. remain the same
22. High blood glucose may be caused by:
   a. not enough insulin*
   b. skipping meals
   c. delaying your snack
   d. large ketones in your urine
23. Which one of the following will most likely cause an insulin reaction:
   a. heavy exercise*
   b. infection
   c. overeating
   d. not taking your insulin

*Correct answer

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