Factors affecting diabetes knowledge in Type 2 diabetic veterans

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Abstract

Aims/hypothesis. To describe the clinical, psychological and social factors affecting diabetes knowledge of veterans with established Type 2 diabetes.

Methods. We conducted an observational study of 284 insulin-treated veterans with stable Type 2 diabetes. All subjects completed the University of Michigan Diabetes Research and Training Centre Knowledge Test, the Diabetes Care Profile, the Mini-Mental State Examination, the Geriatric Depression Scale, and the Diabetes Family Behaviour Checklist. Stepwise multiple linear regression was used to develop a model for the diabetes knowledge score based upon clinical and psychosocial variables.

Results. One hundred eighty subjects were evaluated in a derivation set. The mean age $\pm$ SD was 65.4 ± 9.6 years, 94% were men, and 36% were members of a minority group. Performance on the diabetes knowledge test was poor ($64.9 \pm 15.3\%$ correct). Self-per-

ceived understanding of all management objectives explained only 6% of the variance in the knowledge scores. Multivariate analysis showed that age, years of schooling, duration of treatment, cognitive function, sex, and level of depression were independent determinants of the knowledge score. When the model was applied to 104 subjects in a validation set, there was a strong correlation between observed and predicted scores ($r=0.537$; $p<0.001$).

Conclusions/interpretation. Stable, insulin-treated veterans have major deficiencies in diabetes knowledge that could impair their ability to provide self-care. A multivariate model comprised of demographic variables and psychosocial profiling can identify patients who have limited diabetes knowledge and be used to assess individual barriers to ongoing diabetes education. [Diabetologia (2003) 46:1170–1178]

Keywords Type 2 diabetes mellitus, knowledge, self-care.

Patient education is the cornerstone of care for patients with Type 2 diabetes mellitus. Knowledge of diabetes forms the basis for informed decisions about diet, exercise, weight control, blood glucose monitoring, use of medications, foot and eye care, and control

of macrovascular risk factors. The American Diabetes Association has acknowledged the importance of this concept by adopting 10 standards concerning the structure and process of diabetes educational programs. These recommendations include evaluating the educational needs of patients, developing individualized teaching plans, and periodically re-assessing patient outcomes [1].

Patients receive much of their instruction when the diagnosis is first made. Attention should also be given to the re-training of patients who have had diabetes for a number of years. However, there is uncertainty about how these patients should be selected or the topics that should be reviewed. In addition, although diabetes knowledge is influenced by cultural

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Abbreviations: DOVES, Diabetes Outcomes in Veterans Study; VA, Veterans Affairs; ADA, American Diabetes Association.

factors, attitudes, readiness to learn, depression, cognitive function, family support and barriers to care [2, 3, 4, 5], few studies have used multivariate analysis to quantify their independent effects on diabetes knowledge. These issues are important because patients with longstanding Type 2 diabetes are at increased risk for dementia, stroke, depression, the cumulative effects of hypoglycaemia, and a variety of co-morbidities that affect cognitive function. The purpose of this study was to evaluate the performance of stable, insulin-treated veterans on a standardized test of diabetes knowledge, to measure the effect of a variety of psychosocial factors on test performance, and to develop and validate a method for identifying patients who have limited ability to learn or retain information.

Subjects and methods

The Diabetes Outcomes in Veterans Study (DOVES) is a prospective, observational study of risk factor control in stable, insulin-treated veterans with Type 2 diabetes mellitus. The primary objective of DOVES was to identify problems with implementing methodologies shown to improve outcomes in Type 2 patients. DOVES was conducted under the auspices of the Southwestern Group for Outcomes Research in Diabetes, a consortium of the largest VA facilities in Veterans Integrated Service Network 18. We identified potential subjects by screening computer pharmacy records at the New Mexico VA Health Care System, the Carl T. Hayden VA Medical Center, and the Southern Arizona VA Health Care System. Patients were eligible for this study if they had Type 2 diabetes, took at least one injection of a long-acting insulin preparation daily, had no major medication changes in the preceding two months, did not suffer from alcoholism or substance abuse, had living arrangements conducive to self-care, and had no co-morbidities affecting glucose homeostasis. All subjects provided informed consent and the institutional review boards at each site approved the study protocol.

Baseline evaluation. Research co-ordinators reviewed medical records, interviewed the subject, and measured height, weight, BMI, blood pressure, fasting glucose, haemoglobin A_{1c} (HbA_{1c}), cholesterol, triglycerides, high density lipoprotein, and low density lipoprotein. Subjects were asked about the presence of micro- and macrovascular complications. Subjects were also asked a series of questions on minority status, cultural background, living arrangements and means of transportation, family obligations, occupation, and financial circumstances. Subjects were asked to describe their race or ethnicity using the categories of non-Hispanic white, Hispanic, Native American, African-American and Asian. Subjects also had the option to check an "other" category and write in a response. Bi-racial subjects were classified as minorities. Subjects rated their physical ability to do the following activities: work, yard work, household projects, shopping, exercise, cooking, light housekeeping, or personal care. These activities were classified by frequency, duration, and intensity. Average metabolic-hours per week were calculated based on the Compendium of Physical Activities [6]. Subjects also answered detailed questions about their medical treatment including insulin dose, number of injections, types of preparations, and the dose, type, and frequency of oral medications.

Subjects then completed a battery of psychosocial instruments in private sessions. The number of testing sessions was variable, depending upon the subject's ability to complete the testing within a given session. The instruments were administered in random order and the research coordinator was present to provide instructions, clarify items, and answer any questions. The University of Michigan Diabetes Research and Training Center Knowledge Test [7], a 23-item questionnaire designed for patients on insulin, was used to assess diabetes knowledge and the raw score was converted to percent correct. The Mini-Mental State Examination [8] was used to evaluate cognitive function and the 30-item Geriatric Depression Scale [9] was used to screen for depression. The Diabetes Family Behavior Check List [10] rated the degree of family support. The separate scores for supportive and non-supportive behaviors were combined to produce a composite score. The Diabetes Care Profile [11], an instrument developed at the University of Michigan to measure attitudes towards self-care, was used to assess psychological state. This questionnaire includes 14 subscales: problems with glycaemic control; impact of diabetes on social and personal activities; positive attitudes; negative attitudes; perceived ability to do self-care; importance of self-care; perceived adherence to self-care behaviours; perceived adherence to diet; barriers to taking medications; barriers to exercise; barriers to self monitoring of blood glucose; understanding management objectives; perceived long-term benefits of treatment; and degree of social support. All items were scored on a five-point scale.

Diabetes education in the population reported in this study is delivered through several venues including nutrition clinics, diabetes group classes, and individual teaching sessions. Nutrition classes provide instruction on basic principles, content of foods, daily allowances, desirable weight ranges, and daily planning. Advanced nutrition classes focus on carbohydrate counting for patients who self-titrate their insulin doses or use insulin pumps and specific nutritional or weight problems encountered by each patient. Meal diaries are often used to individualize feedback. The diabetes group classes cover a broad range of subjects such as the natural history of diabetes, exercise, weight control, foot and eye care, blood glucose monitoring, and treatment options. The format varies from site-to-site and from year-to-year but generally consists of four to six sessions given at weekly intervals. Instruction is based upon the clinical practice recommendations of and instructional materials provided by the American Diabetes Association (ADA). Individual training in blood glucose monitoring and insulin therapy is provided by nurses, certified diabetes educators, or providers in primary care or special clinics. Patients may also be referred to the latter for continuous individualized instruction. The focus of these sessions is to review dietary habits, analyze glucose readings, and adjust insulin therapy.

A substantial proportion of subjects in this study developed diabetes before they applied for VA care, and a minority continued to be followed by private practitioners. As a result, it was not possible to verify all of the education that they received. However, the Diabetes Care Profile contains questions on prior training in 12 topics, self-rated understanding of 10 management strategies, whether the subject received enough education to understand diabetes, and whether the subject would like more instruction. Self-rated understanding of management strategies was rated on a 1 to 5 scale (5=most favorable). Overall understanding of management objectives was the average of the responses to the 10 individual strategies.

Questions on the diabetes knowledge test were grouped according to topic. In some instances (e.g., hypoglycaemia caused by insulin), the question was assigned to multiple topics (e.g. complications and medical treatment). The effect of

training on reported levels of understanding and knowledge scores were then examined for each topic. As the Diabetes Care Profile and knowledge test are independent instruments, it was not possible to test the fund of knowledge for all topics reported by the subjects.

Analytical methods. In this study, a random number generator was used to allocate subjects to a derivation set and a validation set. The criteria were set so that approximately 60% were assigned to the former group. Descriptive statistics were used to characterize subjects in the derivation set. Continuous variables were expressed as mean $\pm$ standard deviation (SD). Univariate analysis was used on the derivation set to examine the relationship between the diabetes knowledge score and a variety of demographic, clinical, and psychosocial variables. We evaluated a number of potential family and occupational barriers to continuing education, including living alone, having dependents, having a family member with alcoholism or disability, serving as a caregiver, being employed, and having a variable job site or night job. Multiple linear regression analysis was used on the derivation set to develop a model predictive of the diabetes knowledge score. Independent variables were entered in a stepwise fashion with an alpha of less than 0.10 to enter and greater than 0.10 to remove. Analysis of variance was used to test the fit of the final model. A plot of the residuals compared with estimates was examined to determine if the assumptions of linearity and homoscedasticity were met. A semi-probability plot was used to test for normality of the residuals. Outliers were identified by their studentized residuals and Cook's distances and highly influential points by their leverage. The multivariate model was then used to calculate a predicted knowledge score for the subjects assigned to the validation set. The relationship between the predicted and actual score was tested by simple linear regression. The model was also fitted to the validation set. Components of the model were considered significant predictors of test performance in the new set if the *p* value for their coefficients was less than 0.05. Analyses were carried out using Systat [12].

Results

The protocol was completed by 284 subjects and of these 180 were randomly allocated to the derivation set and 104 to the validation set. The mean age ($\pm$ SD) of the derivation set was 65.4 $\pm$ 9.6 years, 94% were men, and 36% were members of a minority group (Table 1). Although the subjects had diabetes for 15.1 $\pm$ 10.3 years and had been on insulin for 7.9 $\pm$ 8.0 years, performance on the diabetes knowledge test was poor (Fig. 1). The mean score for the derivation group was 64.9 $\pm$ 15.3% correct. The most commonly missed questions are shown in Table 2. The majority of subjects apparently did not understand the meaning of the terms "ketoacidosis", "insulin reaction", "free food", "haemoglobin A_{1c}", or "carbohydrate". The most common wrong answers included 46% of subjects answering that intermediate-acting insulin would cause insulin reactions in 1 to 3 h; 43% answering that corn was high in fat; 43% answering that low blood glucose was a sign of ketoacidosis; 39% answering that they would take the usual breakfast insulin dose at lunch if they forgot to take insulin at breakfast; and

Table 1. Clinical features of study subjects (derivation set)

Race	
Caucasian	64%
Hispanic	22%
African American	12%
Other	3%
Duration of:	
Diabetes	15.1 $\pm$ 10.3 years
Medical treatment	13.1 $\pm$ 9.5 years
Insulin treatment	7.9 $\pm$ 8.0 years
Insulin treatment	
Units per day	63.7 $\pm$ 40.8
Injections per day	2.1 $\pm$ 0.7
Number of preparations	1.5 $\pm$ 0.5
Proportion taking oral hypoglycaemic agents	35.2%
Number of preparations	1.4 $\pm$ 0.6
Number of dosing times	2.0 $\pm$ 0.6
Entry HbA _{1c}	8.2 $\pm$ 1.7%

Fig. 1. Distribution of University of Michigan Diabetes Knowledge Test scores for insulin-requiring veterans with Type 2 diabetes

35% answering that not taking insulin would most likely cause an insulin reaction.

Educational records were reviewed for the 180 subjects in the derivation set, 73% were given the diagnosis of diabetes before they applied for care at one of the sites and presumably received much of their training from other sources. On average, the derivation patients had attended VA clinics for 8.4 $\pm$ 5.0 years. During this time, 77% had attended at least one nutrition clinic and 59% a group class. The most recent visits for these two activities occurred 22.0 $\pm$ 30.4 and 35.5 $\pm$ 40.4 months, respectively, before enrollment to this study. Knowledge scores were higher among those who had attended a group class (67.9 $\pm$ 14.1 vs 62.9 $\pm$ 15.9% correct; *p*=0.03) but not among those who had attended a nutrition clinic. No relationship was found between performance on the knowledge test and the time from the most recent educational activity. Individual teaching sessions took place in a variety of settings and were not separately documented. Unfortunately, of the 48 patients who were diagnosed with diabetes at one of the sites, 12% did not attend a nutrition clinic and 31% did not attend a group class at any

Table 2. Most commonly missed questions on the Diabetes Knowledge Test

Item	% Incorrect	Question (correct answer is in bold)
13	87%	Signs of ketoacidosis include: a. Shakiness b. Sweating c. Vomiting d. Low glucose
23	70%	Which one of the following will most likely cause an insulin reaction? a. Heavy exercise b. Infection c. Overeating d. Not taking your insulin
3	68%	Which of the following is highest in fat? a. Low fat milk b. Orange juice c. Corn d. Honey
4	58%	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
17	58%	If you have taken intermediate-acting insulin (NPH or Lente), you are most likely to have an insulin reaction in: a. 1–3 hours b. 6–12 hours c. 12–15 hours d. more than 15 hours
5	56%	Glycosylated haemoglobin (haemoglobin A _{1c}) 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
2	50%	Which of the following is highest in carbohydrate? a. Baked chicken b. Swiss cheese c. Baked potato d. Peanut butter
8	43%	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
18	42%	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
7	35%	What effect does unsweetened fruit juice have on blood glucose? a. Lowers it b. Raises it c. Has no effect
21	30%	If you take your morning insulin but skip breakfast, your blood sugar will usually: a. Increase b. Decrease c. Remain the same
22	30%	High blood glucose may be caused by: a. Not enough insulin b. Skipping meals c. Delaying your snack d. Large ketones in your urine

time during 11.0 ± 4.0 years of treatment. It was common for patients in the derivation set to cancel or skip scheduled teaching sessions.

As it was not possible to document all of the prior educational activities for the subjects in this study, the Diabetes Care Profile was used to survey the areas in which the patients had been given training (Table 3). Nearly all of the subjects in the derivation set had received instruction in diet, exercise, and glycaemic control. A small but disconcerting proportion did not recall receiving education in weight control, use of diabetic medications, diabetic complications, eye or foot care, or symptoms of hypo- or hyperglycaemia. Instruction was given least often for interactions between diabetic and other medications and for the effects of alcohol. Knowledge scores were highest for the two questions on foot care and exercise and poorest for hypoglycaemia. We compared the self-reported level of understanding for subjects who did or did not receive education in individual topics (Table 4). Sub-

jects who were trained in diet, glycaemic control, weight control, and exercise reported the same level of understanding as those who were not. The inability to detect differences may have been due to the small numbers of untrained subjects. Significant differences in the perceived level of understanding were found for the remaining six topics. Although subjects trained in diabetes medications and complications reported higher levels of understanding than those who didn't, no group differences were found in their knowledge of medications, micro- or macrovascular complications, or hypoglycaemia.

Although overall understanding of management objectives was correlated with knowledge scores ($r=0.237$; $p=0.004$), the former explained only 6% of the variance in the latter. Subjects with higher knowledge scores also perceived fewer barriers to blood glucose monitoring ($r=0.211$; $p=0.006$). However, performance was not related to positive or negative attitudes, perceived self-care skills, importance of self-care, perceived long-term benefits of treatment, social support, problems with glycaemic control, disease impact, or perceived adherence to self-care, diet, exercise or medications. Of the derivation subjects 75% believed that they had received enough information to manage their diabetes. This group reported higher overall understanding for management objectives than those who did not share that belief (3.48 ± 0.81 vs 2.82 ± 0.52 , respectively; $p<0.001$). However, they did no better on the diabetes knowledge test ($65.5 \pm 16.4\%$ vs $61.8 \pm 11.1\%$ correct, respectively; $p=NS$). Seventy-five percent expressed a desire for more education but no differences were found in reported levels of understanding or knowledge scores between patients who did or did not want additional instruction.

The results of univariate analysis looking at the associations between categorical patient variables and diabetes knowledge are shown in Table 5. Tests scores were higher in subjects who preferred communicating in English, and were younger, more highly educated,

Table 3. Self-reported educational activities

Subject area	% Reporting Instruction	% Answers Correct
Diet	96.8%	$60.0 \pm 20.1\%$
Weight control	92.4%	—
Exercise	96.8%	$92.7 \pm 26.1\%$
Medication use	93.6%	$62.4 \pm 26.7\%$
Foot care	94.9%	$91.6 \pm 27.9\%$
Diabetic complications	91.0%	$62.2 \pm 19.4\%$
Micro- or macrovascular		$67.3 \pm 20.2\%$
Hypoglycaemia		$58.8 \pm 25.4\%$
Eye Care	91.1%	—*
Medication interactions	59.2%	—*
Alcohol consumption	84.1%	—*
Glycaemic control	95.6%	$60.1 \pm 19.4\%$
Hypoglycaemia symptoms	91.7%	—*
Hyperglycaemia symptoms	91.1%	—*

* Not covered by the knowledge test

Table 4. Self-reported level of understanding and knowledge scores by type of education

	Level of understanding			Knowledge scores		
	Instructed	Not Instructed	<i>p</i> value	Instructed	Not Instructed	<i>p</i> value
Diet and glucose control	3.28 ± 1.00	3.00 ± 0.76	NS	61.0 ± 15.9	53.8 ± 17.9	NS
Weight control	3.21 ± 1.03	2.92 ± 1.17	NS	—	—	—*
Exercise	3.29 ± 1.02	3.00 ± 0.00	NS	100.00 ± 0.00	91.4 ± 28.1	NS
Diabetic medications	3.57 ± 0.94	2.40 ± 0.84	0.001	62.9 ± 26.2	65.0 ± 31.6	NS
Foot care	3.65 ± 0.94	2.50 ± 1.07	0.006	100.00 ± 0.00	91.2 ± 28.4	NS
Diabetic complications	3.47 ± 0.94	2.21 ± 1.05	<0.001	62.9 ± 19.1	62.1 ± 20.1	NS
Micro- and macrovascular	—	—	—	68.4 ± 19.8	62.5 ± 27.3	NS
Hypoglycaemia	—	—	—	59.3 ± 25.2	61.9 ± 25.7	NS
Eye care	3.51 ± 0.92	2.36 ± 1.01	<0.001	—	—	—*
Medication interactions	3.32 ± 1.00	1.84 ± 1.05	<0.001	—	—	—*
Alcohol effects	3.71 ± 1.06	2.38 ± 1.35	<0.001	—	—	—*

* Not covered by the knowledge test

Table 5. Diabetes knowledge scores by patient characteristics

	Percent correct answers (SD)	<i>p</i> value
Demographic		
Sex		0.013
Male	64.2±15.2	
Female	75.9±13.5	
Marital status		NS
Married	64.5±14.0	
Not married	65.5±17.1	
Race/Ethnicity		0.003
Non-Hispanic white	60.2±17.8	
Minority	67.4±13.0	
Preferred language		0.010
English	65.5±15.6	
Other	53.3±11.0	
Family barriers		
Dependents		NS
Yes	65.1±14.4	
No	64.8±16.3	
Family member with alcoholism		NS
Yes	71.0±14.8	
No	64.3±15.3	
Family member with disability		NS
Yes	65.1±15.2	
No	64.8±15.6	
Patient as caregiver		NS
Yes	65.6±15.0	
No	64.4±15.7	
Occupational barriers		
Employment		NS
Employed	67.2±13.6	
Unemployed/retired	64.2±15.8	
Work shifts		NS
Night hours	72.2±14.3	
Daytime hours	64.3±15.3	
Job site		NS
Variable	67.7±12.2	
Fixed	64.7±15.6	

and not members of a minority group. Women also did much better than men. Marital status and potential family or occupational barriers to continuing education had no effect on performance. Age ($r=0.336$, $p<0.001$), years of schooling ($r=0.353$, $p<0.001$), work hours ($r=0.151$, $p<0.044$), and Mini-Mental State score ($r=0.382$, $p<0.001$) were all correlated with diabetes knowledge. Disease duration, duration of treatment, years of insulin use, presence of depression, and degree of family support also did not affect test scores (data not shown).

Stepwise multiple linear regression on the derivation set showed that the following were independent predictors of diabetes knowledge (Table 6): age, years of schooling, duration of medical treatment, Mini-Mental State Examination score, depression score, and sex ($r=0.548$; $p<0.001$). The last two terms did not quite reach statistical significance. Analysis of residuals showed that this model provided a good descrip-

Table 6. Multivariate model for diabetes knowledge scores

Variable	Coefficient	Standardized Coefficient	<i>p</i> value
Constant	35.7	–	0.034
Age	–0.474	–0.296	<0.001
Years of schooling	1.03	0.208	0.003
Duration of treatment	0.247	0.153	0.028
MMSE score	1.62	0.242	0.001
Depression score	–0.262	–0.114	0.092
Sex	7.83	0.123	0.062

Fig. 2. Relationship between predicted (x-axis) and actual (y-axis) test scores for 104 subjects in the validation set

tion of the data. Only four of 180 subjects were identified as outliers.

The model was used to calculate predicted knowledge scores for the 104 subjects in the validation set. The mean age of this group was 65.0 ± 10.6 years, 90% were men, and 26% were members of a minority group. Fig. 2 shows the relationship between predicted and actual score. The model performed nearly as well in the validation set as it did in the derivation set ($r=0.537$; $p<0.001$). Regression diagnostics showed that the model provided an excellent description of test performance of this sample. When the model was fitted to the new sample, age, education, Mini-Mental Status score and depression score were again identified as significant variables.

Discussion

Successfully managing Type 2 diabetes requires a life-long commitment to self-care. As patients are the most important decision-makers, they should receive enough instruction to make informed decisions about their treatment. However, there is surprisingly little data on knowledge levels of patients who have had diabetes for a number of years. We conducted a cross-sectional analysis of a large cohort of stable, insulin-treated veterans to assess their fund of diabetes knowledge and to identify the clinical, psychological, and

social factors that might have an adverse effect on their ability to learn or retain information.

We found that our subjects' performance on a standardized test of diabetes knowledge was surprisingly poor. Even though 85% received some high school education and 46% some post-secondary education, a substantial proportion did not understand their treatment plans. Nearly half did not know when they were at greatest risk for hypoglycaemia or were not able to identify appropriate treatment options. We expected that many of our subjects would miss the question on ketoacidosis because this complication is uncommon in Type 2 diabetes and we excluded patients with a history of ketoacidosis. However, the terms "insulin reaction", "free food", "haemoglobin A_{1c}", and "carbohydrate" could be commonly used by health care providers. Even more worrisome was the observation that a substantial proportion of subjects did not understand the relationship between insulin and blood sugar, when low blood sugars were most likely to occur with the medications they were taking, or how they should treat those episodes. These observations dramatically reinforce the ADA's recommendations for periodically re-assessing educational needs and identifying barriers to ongoing education [1].

The ADA also recommends that a teaching plan be tailored to the individual's needs—a process that requires a review of attitudes, cultural influences, readiness to learn, cognitive ability, physical limitations, family support, and financial status. We systematically evaluated these factors except for the latter because our subjects received their care through a common entitlement. We also evaluated a number of family and occupational barriers that could have prevented them from participating in ongoing educational programs. Patients with poorer knowledge scores perceived greater barriers to blood glucose monitoring. However, performance was not correlated with positive or negative attitudes, social support, self-care abilities, or perception of long-term benefits as measured by the Diabetes Care Profile. These observations are at variance with a large number of studies that showed that the ability of patients to learn is highly influenced by attitudes and beliefs [13, 14, 15, 16, 17, 18]. There are several explanations for this discrepancy. Our study focused on patients who had completed much of their education years prior to the knowledge test. One possibility is that attitudes are more important during the initial training than they are for ongoing education. Another is that attitudes become less influential with the passage of time because of the increasing prevalence of depression or cognitive dysfunction. Finally, although subjects were randomly selected, those with poor attitudes could have chosen not to participate in the study.

Training in specific topics increased self-reported levels of understanding but did not enhance knowledge in those same areas. In addition, subjects who re-

ported that they did not need or desire additional education did no better on the knowledge test than those who expressed the opposite point of view. Finally, self-perceived understanding of management objectives explained only a small proportion of the variance in performance on the knowledge test. These observations suggest that self-perceptions are not adequate to assess the adequacy of training in this population and that formal testing should be done to evaluate the results of their educational activities.

We confirmed that years of schooling, cognitive function, and depression are major determinants of diabetes knowledge. However, we have also shown an independent effect for patient age and sex that could not be attributed to disease duration or access barriers arising from family or job commitments. Women and younger patients could have greater motivation, adaptability, or an internal locus of control [19] that drives learning behaviour. These traits were not measured in this study but should be evaluated in future investigations. In addition, although knowledge scores were lower in minorities and in those who preferred a language other than English, neither term entered into the multivariate model. This finding suggests that some cultural effects might be mediated through other components of the model.

Finally, we have shown that a multivariate linear model based upon these characteristics can predict the fund of knowledge in an independent sample of patients. The predicted score explained nearly 30% of the variance in test performance. We are unaware of previous studies in which a model of diabetes knowledge has been so vigorously validated. This analysis confirms that age, gender, duration of treatment, cognitive function, depression, and years of schooling remain important determinants of diabetes knowledge. This finding has major implications for the design of patient education programs. Although the model does not determine whether the problem is the inability to learn or to retain information, it does identify those at risk for a poor fund of knowledge during the chronic phase of their illness. It also quantifies potential barriers to the learning process.

Better outcomes for diabetes classes might be achieved if patients were grouped according to their capacity to learn. Our study suggests that these groupings might be made on the basis of demographic factors or years of schooling. Psychological counseling should be heavily emphasized in those with depression. The level of course materials should be lowered or training of a spouse or caregiver should be considered for those who have cognitive dysfunction.

We took several precautions to assure that our testing program was appropriate. A research coordinator was present to answer any questions. Questionnaires were given in random order. Sessions were tailored to meet individual needs and were designed to minimize fatigue. Finally, the knowledge test was rated for lan-

guage proficiency and found to be appropriate for the great majority of our subjects.

The approach to diabetes education in the United States is based upon ADA recommendations which specify the elements and topics to be covered. Programs which satisfy ADA requirements are certified and provide essential information to patients who participate. Considerable variability in the methods is accepted and even encouraged, and individualization of instruction is emphasized. In contrast, the European approach tends to be more structured and emphasizes group education [20]. This approach has been successfully adapted for use elsewhere including 10 Latin American countries [21].

There are several factors that make it difficult to compare our study to those using the European strategy. A comprehensive review of the European experience [20] concluded that patient education programs could not be evaluated without considering other aspects of the overall management plan. This conclusion was supported by a recent study of diabetes management in the United States based upon risk stratification and social marketing [22]. Patient education was an important and integral part of this successful approach. Many of the earlier studies focused on Type 1 diabetes [23, 24] or were published before current approaches were standardized [25]. As Type 1 patients are younger, they are less vulnerable to a host of factors that impair learning in older patients such as stroke, dementia, depression, alcoholism, and unfavourable social circumstances. Our study used only the most immediate outcome of the education process—the acquisition of factual information—while larger trials often used behavioural or clinical endpoints [20]. Finally, this study was designed to identify patient-related risk factors for failures within an American system of diabetes education, not to test the strengths and weaknesses of its components. Our findings suggest that patient misperceptions of understanding, lack of formal knowledge testing, and the neurological consequences of aging might be more important causes for poor performance than the educational system itself. Our results draw attention to the knowledge status of patients with Type 2 diabetes mellitus who have had access to programs that meet current standards. The results are clearly disappointing. This information could be useful in designing future studies on evaluating patient knowledge and developing better approaches.

In conclusion, insulin-treated veterans with stable Type 2 diabetes have major deficits in diabetes knowledge. The degree of deficiency is not strongly correlated with attitudes but is highly influenced by demographic and clinical factors, depression, years of schooling and cognitive function. A multivariate model based upon these factors can identify stable patients who have the inability to learn or retain information and quantifies potential barriers to the educational

process. Our study reinforces the ADA recommendations for periodic re-assessment of patient knowledge and the use of educational strategies that are matched to the patient's abilities.

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