Table 1—*Sensitivity and specificity of the ADA diabetes risk test in a community screening program*

Group	*n*	Sensitivity of risk test (%)	Specificity of risk test (%)	Prevalence of diabetes and IGT (%)	Positive predictive value
Total	396	80	34.6	8.8	11.9
African-American	148	90.9	24.8	7.4	9.7
Caucasian	198	72.7	40.9	11.1	13.3
Female	309	84.6	32.2	8.4	10.3
Male	85	66.7	43.4	10.6	12.2

Demographic information, risk test scores, and plasma glucose levels were recorded. Individuals with abnormal glucose levels received follow-up testing. Abnormal glucose levels were defined as a fasting glucose >109 mg/dl or a random glucose >159 mg/dl, levels that define impaired glucose tolerance (IGT) or diabetes. A positive ADA risk test was defined as a score of ≥10.

Of the >1,000 individuals who attended these programs, 396 people both completed the risk test and had their plasma glucose measured. The average age of the participants was 51.0 ± 15.0 years (SD). Although our data were not collected as part of a randomized trial, they provide information on the utility of the risk test in a community screening program (Table 1).

For the risk test to be of value, the sensitivity should be high, since the consequences of not diagnosing the disease are tremendous. Diabetes has preventable complications, and early treatment is necessary. Specificity is less important because the test to rule out diabetes is not burdensome—a fasting plasma glucose test is inexpensive, easy to perform, and minimally invasive.

Given that the test should have a high sensitivity, the ADA risk test performed less than ideally, particularly in Caucasians and males. The risk test is weighted against males because one of the questions is directed at women only. Of the false negatives, four had glucose levels >300 mg/dl. These individuals probably would have been detected based on the recommendation to screen people with symptoms of diabetes.

Our recommendation, given these results, is to de-emphasize the numeric risk score in the ADA's Community Campaign for Diabetes materials. People need to be made aware of risk factors associated with the development of diabetes and of the symptoms of diabetes. Risk factors not included in the ADA risk test, such as hypertension, high-risk ethnicity, history of gestational diabetes, past IGT, and dyslipidemia should also be emphasized (2). It is important to stress that one can have a low score and still have diabetes. The new screening recommendations (2), which advocate screening everyone >45 years every 3 years, beginning earlier and testing more frequently if risk factors are present, should be emphasized rather than a specific risk test score.

PAUL E. KNUDSON, MD
KATHY J. TURNER, MPH
ANN SEDORE, PHD, RN
RUTH S. WEINSTOCK, MD, PHD

From the SUNY Health Science Center (P.E.K., A.S., R.S.W.) and the Onondaga County Health Department (K.J.T.), Syracuse, New York.

Address correspondence to Ruth S. Weinstock, MD, PhD, SUNY Health Science Center, 750 East Adams St., CWB 353, Syracuse, NY 13210.

Acknowledgments— This work was supported by the New York State Department of Health, Joslin Center for Diabetes at SUNY Health Science Center, Syracuse, and the Onondaga County Health Department.

References

1. Herman WH, Smith PJ, Thompson TJ, Englegau MM, Aubert RE: A new and simple questionnaire to identify people at increased risk for undiagnosed diabetes. *Diabetes Care* 18:382–387, 1995
2. The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 20:1183–1197, 1997

Response to Knudson et al.

We congratulate Knudson, Turner, Sedore, and Weinstock on their diabetes outreach activities in Onondaga County (1) and appreciate the opportunity to comment on their findings. Specifically, we appreciate the opportunity to comment on the performance of the diabetes screening questionnaire, "Take the test. Know the score," developed by Dr. Richard Kahn and the American Diabetes Association (ADA) based on our work.

In our work, classification trees were applied to data from the second National Health and Nutrition Examination Survey (NHANES) to identify subsets of people at increased risk for previously undiagnosed diabetes (2). Diabetes was defined by a fasting glucose ≥140 mg/dl or a glucose 2 h after a 75-g oral glucose level ≥200 mg/dl. We found that a classification tree incorporating age, sex, obesity, sedentary lifestyle, family history of diabetes, and history of the delivery of a macrosomic infant was 79% sensitive and 65% specific in identifying individuals with previously undiagnosed diabetes in a representative sample of the U.S. population. To develop the "Take the test. Know the score." questionnaire, the ADA applied arbitrary weights to risk factors to identify subjects in the terminal leaves of the classification tree who were at increased risk.

The performance of this classification tree was essentially identical to that of one that incorporated the same demographic and historical variables and also included history of glucose intolerance and history of hypertension (2). Its performance was, however, significantly better than that of a risk factor questionnaire previously used by the ADA (2). We estimated that use of the classification tree would result in follow-up testing to establish a definitive diagnosis of diabetes in 31% of the total U.S. population (2). The trade-off was that ~20% of individuals with undiagnosed diabetes would be missed with the initial screen (2). We concluded that the primary value of the screening questionnaire was to render a general population to a smaller group that would have a higher prevalence of diabetes, thus making the subsequent application of biochemical tests more efficient. This was particularly important when the definitive diagnostic test for diabetes was the oral glucose tolerance test,

an unpleasant, inconvenient, time-consuming, and expensive procedure.

A number of points in the current report merit specific comment. First and most important is the fact that while we developed the screening questionnaire using the diagnostic criteria for diabetes that were accepted at the time as the "gold standard," Knudson et al. defined a fasting glucose >109 mg/dl or a random glucose >159 mg/dl as the gold standard. They did not state what proportion of subjects actually had diabetes by old or new ADA criteria. In addition, Knudson et al. performed definitive follow-up for only 396 of >1,000 subjects and did not state whether they were representative of the population. In contrast, the NHANES-2 provided follow-up for all subjects and subjects were representative of the U.S. population. When patients with positive screening tests are preferentially referred to receive verification by the gold standard test, work-up or verification bias may occur and may substantially distort sensitivity and specificity (3). The lower specificity of the test in the Onondaga County population may relate either to the fact that the gold standard was defined differently or to work-up bias. Sensitivity and specificity are not constants of nature but depend on the population to which the test is applied (3).

Even despite these differences, the performance of the test was in fact quite similar in the two populations. We also found that the sensitivity of the questionnaire was somewhat higher and the specificity somewhat lower among blacks, Hispanics, and Native Americans compared with whites (2). Although minority populations are more likely to have undiagnosed diabetes than whites, race and ethnicity did not enter into the classification trees (2). This suggests that although individuals conducting screening might want to target high-risk minority populations, the instrument is generally valid because the selected risk factors have the same predictive value in different racial and ethnic populations.

We acknowledge that we did not include other important risk factors, such as history of impaired glucose tolerance, hypertension, dyslipidemia, and history of gestational diabetes, in the questionnaire. This was a conscious decision based on our desire to develop a screening instrument that could be used in all populations, including the medically underserved (as was the population of Onondaga County) (2). The advantage of this approach is that the accuracy of the questionnaire does not depend on the respondents having had prior medical evaluation or care.

We certainly concur with de-emphasizing the numeric scores in the questionnaire, since they have no intrinsic meaning but were merely devised to identify subjects in the terminal leaves of the classification tree.

Although we also concur with the careful assessment of symptoms as a part of any medical evaluation for diabetes, published studies suggest that screening based on symptoms is not of value, since up to one-third of all individuals screened report frequent urination, extreme fatigue, and blurred vision (4–6). Clearly, to the extent that the screening questionnaire serves as an educational tool, it should describe the symptoms of uncontrolled diabetes (as the ADA questionnaire does). More sophisticated probing may, however, be necessary to make sense of these symptoms.

We certainly recognize that with the use of any screening test, false negatives will occur. Generally, this is addressed by establishing a screening threshold with a high sensitivity (7). In addition, periodic rescreening of the population can identify false negative screenees over time (7).

Finally, although we concur with the authors and the ADA that periodic screening is desirable, we continue to believe that further applied research is needed to rigorously evaluate the "who, where, when, and how of screening" and to assess cost-effectiveness (7). Careful predissemination evaluation of screening tests is vital to eliminate useless tests before they receive widespread application (3).

WILLIAM H. HERMAN, MD, MPH
PHILIP J. SMITH, PHD
THEODORE J. THOMPSON, MS
MICHAEL M. ENGELGAU, MD
RONALD E. AUBERT, PHD

From the University of Michigan Medical Center (W.H.H.), Ann Arbor, Michigan; the Centers for Disease Control and Prevention (P.J.S., T.J.T., M.M.E.); and the Prudential Center for Health Care Research (R.E.A.), Atlanta, Georgia.

Address correspondence to William H. Herman, MD, MPH, Division of Endocrinology and Metabolism, Department of Internal Medicine, University of Michigan Medical Center, 1500 E. Medical Center Dr., 3920 Taubman Center, Box 0354, Ann Arbor, MI 48109. E-mail: wherman@umich.edu.

References

1. Knudson PE, Turner KJ, Sedore A, Weinstock RS: Utility of the American Diabetes Association risk test in a community screening program (Letter). *Diabetes Care* 21:1029–1030, 1998
2. Herman WH, Smith PJ, Thompson TJ, Englegau MM, Aubert RE: A new and simple questionnaire to identify people at increased risk for undiagnosed diabetes. *Diabetes Care* 18:382–387, 1995
3. Reid MC, Lachs MS, Feinstein AR: Use of methodological standards in diagnostic test research: getting better but still not good. *JAMA* 274:645–651, 1995
4. Duncan WE, Linville N, Clement S: Assessing risk factors when screening for diabetes mellitus. *Diabetes Care* 16:1403–1404, 1993
5. Newman WP, Nelson R, Scheer K: Community screening for diabetes: low detection rate in a low-risk population. *Diabetes Care* 17:363–365, 1994
6. Burden ML, Burden AC: The American Diabetes Association screening questionnaire for diabetes: is it worthwhile in the U.K.? (Letter) *Diabetes Care* 17:97, 1994
7. Engelgau MM, Aubert RE, Thompson TJ, Herman WH: Screening for NIDDM in nonpregnant adults. A review of principles, screening tests, and recommendations. *Diabetes Care* 18:1606–1618, 1995

Ketoacidosis During Gestational Diabetes

Case report

Gestational diabetes mellitus (GDM) presenting with ketoacidosis is highly unusual. Clinical reports of diabetic ketoacidosis (DKA) during pregnancy relate either to undiagnosed type 1 diabetes (1), to GDM complicated by stress (prolonged labor or infection) (2), or to the use of high doses of glucocorticoids or β-adrenergic receptor agonists for premature labor (3,4). We describe a woman who had GDM complicated by ketoacidosis without any identifiable precipitating factors. She remains nondiabetic 9 months after delivery.

A previously healthy 25-year-old Mauritian woman of African ethnicity, gravida 1, para 0, presented at 32 weeks of gestation with a 2-day history of vomiting, vertigo, polydypsia, and polyuria. She had undergone an O'Sullivan test (50 g of glucose by mouth) with a glycemia of 9.0 mmol/l at 60 min 1 week earlier. There