Performance of an NIDDM Screening Questionnaire Based on Symptoms and Risk Factors

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OBJECTIVE — To investigate to what extent a short questionnaire on symptoms and risk factors can be used to identify people at increased risk for undiagnosed NIDDM.

RESEARCH DESIGN AND METHODS — A general population sample of 2,364 Caucasian subjects, age 50–74 years, not known to have diabetes, completed a questionnaire on diabetes-related symptoms and risk factors. Subsequently, they underwent an oral glucose tolerance test. A backward stepwise multiple logistic regression was carried out with the absence or presence of newly detected diabetes as the dependent variable and the items from the questionnaire as the independent variables. The selected items were included in a new symptom-risk questionnaire, which was evaluated in a different population sample of 786 subjects, age 45–74 years, not known to have diabetes and compared with existing questionnaires.

RESULTS — The newly developed symptom-risk questionnaire contains questions concerning the following items, which were independently and significantly ($P < 0.05$) associated with the presence of previously undiagnosed diabetes: pain during walking with need to slow down, shortness of breath when walking with people of the same age, frequent thirst, age, sex, obesity, parent or sibling with diabetes, use of antihypertensive drugs, and reluctance to use a bicycle for transportation. The 1993 American Diabetes Association questionnaire, the 1995 Herman et al. (17) questionnaire, and the newly developed symptom-risk questionnaire had sensitivities of 59, 72, and 72%; specificities of 57, 55, and 56%; positive predictive values of 5.6, 6.4, and 6.5%; and negative predictive values of 97, 98, and 98%, respectively.

CONCLUSIONS — The newly developed symptom-risk questionnaire has good performance characteristics, and the advantage of a variable cutoff makes it a useful screening tool for NIDDM in general practice.

NIDDM is accompanied by a high risk for micro- and macrovascular disease. Because of the natural history and nonspecific symptoms of the disease, an average of 9–12 years passes before a diagnosis can be established. As a result, ~50% of all subjects with diabetes in Caucasian populations and African- and Mexican-Americans remain undiagnosed (1–3). It is generally accepted that early treatment of diabetes and the often-associated cardiovascular risk factors (e.g., hypertension, lipid disturbances) may reduce the occurrence of complications. However, early detection is costly and inconvenient, and there is no suitable population screening test (4–12). A potentially cost-effective and initially noninvasive approach might be the use of a questionnaire to identify individuals at increased risk, followed by blood glucose testing to establish a diagnosis. Items of such a questionnaire could also be used in symptom awareness campaigns (13). The American Diabetes Association (ADA) developed a questionnaire (AD-Q) based on symptoms and risk factors to increase public awareness and to identify diabetes (14). The publication of this questionnaire resulted in heated discussions about the value of risk factors and symptoms in the prediction of diabetes. In 1994, Burden and Burden (15) stated that they did not consider the AD-Q to be useful in the U.K. In 1993, Duncan et al. (16) reported that preselection on the basis of one or more risk factors was unsatisfactory, which is in contrast to Engelgau et al. (12) and Herman et al. (17), who suggested in 1995 that a questionnaire that uses risk factors could be an efficient tool in a diabetes screening program.

We investigated to what extent in a general Caucasian population a questionnaire on symptoms and risk factors could be used to identify individuals at increased risk for undiagnosed NIDDM. We developed a questionnaire based on information from one general population sample and validated it in another population sample. Furthermore, we compared its diagnostic value with the AD-Q and the classification tree questionnaire (CT-Q) of ADA (14) and Herman et al. (17), respectively.

RESEARCH DESIGN AND METHODS

Questionnaire development study (population A)

Subjects. We used data from the Hoorn Study, in which a random sample of 50- to 74-year-old subjects was taken from the population register of the town of Hoorn in the Netherlands (57,000 inhabitants). Of the 3,553 subjects invited, 2,540 (71.5%) participated, of whom 56 were excluded from analysis because they were non-Caucasian. Thus, the final Hoorn Study cohort consisted of 2,484 subjects, as described previously (18). All subjects who reported having diabetes (n = 104) were excluded from the present analysis.

Questionnaire. Participants completed a detailed questionnaire on symptoms and risk factors with a plausible physiological

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ADA, American Diabetes Association; AD-Q, 1993 American Diabetes Association questionnaire; CT-Q, classification tree questionnaire; IQR, interquartile range; NDM, newly detected diabetes; OGTT, oral glucose tolerance test; ROC, receiver-operator characteristic; WHO, World Health Organization; SR-Q, symptom-risk questionnaire.

connection with diabetes before visiting the study center. Questions on symptoms commonly considered related to a high glycemic level included the following: tiredness, itching, voiding large amounts of urine, frequent thirst, and recent weight loss. The self-administered Dutch translation of the cardiovascular questionnaire of the London School of Hygiene and Tropical Medicine was used to assess angina pectoris and intermittent claudication (19). A number of items were added to detect congestive heart failure. Neurological symptoms were investigated by asking questions about pain at rest in the legs or feet and about numbness and tingling in the hands or feet. Ophthalmic abnormalities were assessed based on short and farsightedness, blurry vision, or constant impairment of vision (including the type of correction aid used, if applicable). The risk factor items included age, sex, positive family history of diabetes, gestational diabetes, giving birth to heavy (macrosomic) infants (>4,500 g), hypertension, and physical activity. Physical activity was measured by asking nine questions about regular performance of the following activities: playing sports, cycling, gardening, walking, doing odd jobs, climbing the stairs at home, doing household activities, doing daily food shopping, and working, whether paid or unpaid (18). Except for age, which was categorized per 5-year increment, all items were transformed into dichotomous variables (yes/no).

Oral glucose tolerance test. Participants underwent a 75-g oral glucose tolerance test (OGTT) and were classified according to the World Health Organization (WHO) criteria (20). A second OGTT (participation rate 92%) was performed within 3–5 weeks on every subject with a 2-h glucose value in excess of 7.5 mmol/l and with a random subsample stratified by age and sex (21). If available, the mean glucose value was used in the analysis. The venous plasma glucose value was determined according to a glucose dehydrogenase method (Merck, Darmstadt, Germany).

Biometry. During their visit, height and weight of the subjects were measured without shoes and outergarments, and the BMI was calculated as weight (kilograms) divided by height (meters) squared. Obesity was defined as BMI >29.0 kg/m^2 for women and >30.0 kg/m^2 for men.

Analysis. To select symptoms and risk factors that could be used to identify subjects at increased risk for undiagnosed diabetes, we performed an analysis in three phases. First, logistic regression analyses were carried out with the presence or absence of newly detected diabetes (NDM) as the dependent variable and with each of the symptoms or risk factors, together with sex and age, as the independent variables. Any symptom or risk factor associated with NDM at a significance level of $P < 0.20$ was included in the next phase of the analysis. Second, from the five different groups (diabetes-related symptoms, cardiovascular symptoms, neurological symptoms, ophthalmological symptoms, and risk factors), items were selected that showed an association with NDM at a significance level of $P < 0.10$ in a backward stepwise procedure in each group. When highly correlated items showed a similar association with NDM, preference was given to those which were the least complex and thus easier to answer. Third, the backward stepwise procedure was repeated with the remaining symptoms and risk factors, again using $P < 0.10$ as the selection criterion. In this last phase, attention was also paid to possible interaction between variables in order to increase the predictive value of the final model. This model contained all the final selected items together. The probability of a particular individual having undiagnosed diabetes, as predicted by the final regression equation, can be computed by substituting individual values for the predicting variables x_1, x_2, x_3, etc. in the following:

$$p(\text{NDM}) = [1 + e - (a + b_1x_1 + b_2x_2 + \dots)]^{-1}$$

where p(NDM) represents the probability of having diabetes, a represents the constant, and b_1, b_2, etc. represent the regression coefficients of the predictors x_1, x_2, etc. (22). To enable future respondents to compute their own risk for diabetes, the regression coefficients associated with the various items were transformed (multiplied by 5 and rounded off to the nearest integer) into simple scores that can be added up to obtain an aggregate score. The individual risk for diabetes can be computed by substituting 0.2 multiplied by the aggregate score instead of $b_1x_1 + b_2x_2 + \dots$ in the above formula. Analyses were performed with the SPSS-PC software package, version 5.0.

Questionnaire validation study (population B)

For this study, a different random sample of 45- to 74-year-old subjects was taken from the population register of the town of Hoorn. These subjects were neither former participants of the Hoorn study nor known to have diabetes. Of the subjects who received a postal invitation to undergo a blood glucose test, 53% visited the study center and completed a combined questionnaire that included items selected from the newly developed symptom-risk questionnaire (SR-Q), items translated from the AD-Q, and items from the CT-Q before their fasting venous whole-blood glucose was determined by means of a YSI glucose analyzer (YSI, Yellow Springs, OH). In contrast to the procedure for population A, only subjects with a fasting whole-blood glucose value >4.9 mmol/l, equivalent to a plasma glucose value of 5.5 mmol/l, were given a complete OGTT. In population A, only 0.5% of the subjects with a fasting plasma glucose ≤5.5 mmol/l had a postload plasma glucose value ≥11.1 mmol/l. Subjects with a fasting whole-blood glucose value ≤4.9 mmol/l were considered to have normal glucose tolerance, and subjects who underwent an OGTT were classified according to the WHO criteria (20).

According to data on differences between measured and self-reported weight and height, self-reported BMIs tend to underestimate measured values in obese men and women. These differences vary from 0.3–0.8 kg/m^2 for men in the general population to 1.3 kg/m^2 for obese women (23,30,31). We used these data and reduced the cutoff value of the BMI by 1.0 kg/m^2 for both men and women in the SR-Q, where height and weight were self-reported.

To compare the performance of the AD-Q with that of the SR-Q, we constructed receiver-operator characteristic (ROC) curves. ROC curves characterize the relationship between the true-positive ratio (sensitivity) and the false-positive ratio (1 − specificity). The sensitivity of a test is the probability (0–100%) that the test is positive for patients with diabetes. The specificity is the probability (0–100%) that a test is negative for subjects without diabetes. The points on the curves represent different values of the aggregate score. Curves of tests that perform well aggregate toward the upper left corner of the square. The area under the curve quantifies the diagnostic value of the test: the greater the area under the curve, the better the performance of the test. It varies between 0.5, when the test is no better than chance in correctly categorizing the two groups, and 1.0, when its predictive value is perfect (24–26). To compare the performance of the CT-Q, which permits a classification as "positive" or

"negative" only, with that of the SR-Q and the AD-Q, we calculated their test qualities at one cutoff value.

RESULTS

Questionnaire development study (population A)

Of the participants, 2,364 (population A) completed the OGTTs, which resulted in the identification of 110 subjects with newly detected diabetes (NDM_A). A total of 16 subjects with an unclassifiable OGTT were excluded, of whom 12 had a fasting plasma glucose value of <7.0 mmol/l and 4 had no recorded fasting plasma glucose value. The percentage of subjects with missing information concerning one of the symptoms or risk factors did not exceed 1.4% per item.

Selection of symptoms and risk factors

Table 1 presents the prevalences of symptoms and risk factors in subjects with and without NDM_A and the corresponding odds ratios (ORs) for NDM_A. The items shown were of interest because they were associated with NDM_A or included in either the AD-Q or the CT-Q. The OR of age corresponds to an increment of 5 years. The OR of obesity was highest when the cutoff value for the measured BMI was >29.0 kg/m² for women and >30.0 kg/m² for men. The symptoms and risk factors approved in the second phase of selection were frequent thirst, pain during walking with need to slow down, shortness of breath when walking with people of the same age, frequent tingling in the hands or feet, farsightedness (including the type of correction aid used, if applicable), age, obesity, parent or sibling with diabetes, use of antihypertensive drugs, and reluctance to use a bicycle for transportation. Angina pectoris and intermittent claudication, as measured by the Dutch translation of the cardiovascular questionnaire of the London School of Hygiene and Tropical Medicine, were associated with NDM_A and resulted in ORs (with 95% CIs) of 1.6 (0.8–3.1) and 4.0 (1.3–12), respectively. For the development of a short questionnaire, however, nine items to detect intermittent claudication were considered to be too numerous. Table 2 shows which items were selected in the final (third) phase of selection. The OR of age shows that from age 50 years onward, every increment of 5 years corresponds with an additional score of 2 points. The statistically significant interaction between obesity and sex results in a score of 3 points for women with a measured BMI of >29.0 kg/m² and a score of 8 points for men with a measured BMI of >30.0 kg/m². The aggregate score ranges from zero to a maximum of 34 points for a 74-year-old obese man with all the symptoms and risk factors mentioned in Table 2.

Table 1—*The prevalence of symptoms and risk factors in subjects with and without NDM and ORs of NDM subjects for population A*

	Non-NDM	NDM	OR (95% CI)*
n	2,254	110	
Diabetes-related symptoms			
Often tired ¶	25.8	31.8	1.4 (0.9–2.2)
Often itching	12.4	18.2	1.6 (1.0–2.7)
Voiding large amounts of urine ¶	17.2	20.9	1.2 (0.7–1.9)
Frequent thirst ¶	13.0	25.7	2.5 (1.5–3.9)
Recent weight loss ¶	13.3	14.7	1.1 (0.6–1.9)
Cardiovascular symptoms			
Bout of oppressive chest pain	15.0	22.9	1.6 (1.0–2.6)
Pain during walking	19.1	32.4	2.0 (1.3–3.1)
Pain in calf during walking	6.0	12.0	2.0 (1.1–3.6)
Pain during walking with need to slow down	8.0	20.6	2.8 (1.7–4.7)
Shortness of breath when			
washing/getting dressed	4.0	11.0	2.7 (1.4–5.1)
walking with people of the same age	6.8	20.2	2.8 (1.7–4.7)
Neurological symptoms			
Frequent numbness in hands or feet	12.4	19.3	1.7 (1.1–2.8)
Frequent tingling in hands or feet	15.9	24.8	1.8 (1.2–2.9)
Ophthalmological symptoms‖			
Shortsightedness	9.6	15.5	1.8 (1.1–3.1)
Farsightedness	7.2	13.8	1.9 (1.1–3.5)
Impairment of vision	3.2	8.3	2.3 (1.1–4.9)
Blurry vision from time to time¶	11.0	11.9	1.1 (0.6–2.0)
Risk factors			
Age (median and interquartile range)†¶**	60.5 (55.0–67.1)	66.2 (60.9–72.0)	1.5 (1.3–1.7)
Sex (men)¶**	46.6	46.4	1.0 (0.7–50)
Obesity‡¶**	17.5	41.8	2.4 (1.4–4.2)
Parent or sibling with diabetes¶**	19.8	31.2	1.9 (1.3–2.9)
Macrosomic infant(s)§¶**	1.3	0	—
Use of antihypertensive drugs	13.3	28.7	2.3 (1.5–3.5)
Reluctance to use a bicycle for transportation	23.6	41.3	2.0 (1.3–2.9)

*ORs of symptoms and risk factors for newly detected diabetes, adjusted for age and sex. †OR per 5-year increment. ‡BMI for women >29.0 and men >30.0 kg/m². §Expressed as a percentage of the female subjects. ‖With the type of correction aid used, if applicable. ¶Included in AD-Q (14). **Included in CT-Q (17).

Questionnaire validation study (population B)

The questionnaire was completed by 786 subjects before their fasting whole-blood glucose level was measured. In 15 of 427, a fasting whole-blood glucose value ≥6.7 mmol/l was found, and those subjects were considered to have diabetes. In 53 subjects, a fasting whole-blood glucose value between 4.9 and 6.7 mmol/l was measured, but they were not willing to complete an OGTT. Because their median glucose value was 5.0 mmol/l (interquartile range of the skewed distribution: 4.9–5.0), we considered them as having normal glucose tolerance. Subjects with a fasting whole-blood glucose value ≤4.9 mmol/l (n = 359) were also considered to have normal glucose tolerance, and 359 subjects with a fasting whole-blood glucose level >4.9 mmol/l underwent an OGTT, and were classified according to WHO criteria (19), which finally resulted in the identification of 32 NDM_B subjects. The percentage of subjects with missing information concerning one of the symptoms and risk fac-

Table 2—*Final selection of symptoms and risk factors for the screening tool for population A*

	Regression coefficient	Score*	OR (95% CI)
Constant	−9.07		
Frequent thirst	0.69	3	1.99 (1.22–3.25)
Pain during walking with need to slow down	0.60	3	1.82 (1.04–3.19)
Shortness of breath when walking with people of the same age	0.61	3	1.85 (1.05–3.26)
Age per 5-year increment from 50 years†	0.39	2	1.47 (1.27–1.70)
Sex (0, F:1, M)‡	0.17	—	1.19 (0.70–2.12)
Obesity (F >29.0 kg/m^2: M >30.0 kg/m^2)	0.66	3	1.94 (1.09–3.45)
Obesity, men§	1.02	5	2.78 (1.16–6.64)
Parent or sibling with diabetes	0.69	3	1.98 (1.27–3.10)
Use of antihypertensive drugs	0.67	3	1.94 (1.22–3.12)
Reluctance to use a bicycle for transportation	0.50	3	1.65 (1.07–2.53)

*The score is the regression coefficient multiplied by 5 and rounded off to the nearest integer. †This OR per 5 years results in 2 points for 55–59 years, 4 points for 60–64 years, 6 points for 65–69 years, and 8 points for 70–74 years. ‡Sex only contributes to the instrument in combination with obesity. §Men with obesity are at higher risk for NDM than women, as was shown by an interaction between sex and BMI: women with a BMI >29.0 kg/m^2 receive a score of 3 points, whereas men with a BMI >30.0 kg/m^2 receive a score of 8 points.

tors did not exceed 1.7% per item. The demographic characteristics of population B differed slightly from population A (Table 1). The age (median and interquartile range [IQR]) of subjects with and without NDM_B was 60 (IQR 53–67) and 53 (IQR 48–61). The percentage of subjects who were obese with and without NDM_B was 43.8 and 14.6%, and the percentage of subjects who were men was 59.4 and 45.9%. Population B also differed slightly with respect to prevalence rates of macrosomic infants, pain during walking with need to slow down, and undiagnosed diabetes (4.1 vs. 4.7%, Table 3). Table 3 also shows that the performance of the newly developed SR-Q was better in the population in which it was developed (population A) than in the population in which it was validated (population B). This difference is also illustrated by the area under the ROC curve and the 95% CI of the SR-Q, which was 0.80 (0.75–0.85) for population A and 0.69 (0.60–0.79) for population B (data not shown). A comparison of the SR-Q with and without the item "reluctance to use a bicycle for transportation" shows that the bicycle question does not contribute much to the performance of the SR-Q. The area under the ROC curve in population B with and without the item "reluctance to use a bicycle for transportation" is 0.69 and 0.70 (0.60–0.79), respectively (data not shown).

Comparison of questionnaires

The performance of the SR-Q, CT-Q, and AD-Q as screening tools is shown in Table 4 and Fig. 1 (SR-Q and AD-Q). The CT-Q permits a classification of "positive" or "negative" only, whereas the SR-Q and the AD-Q have a variable cutoff value, and thus make it possible to vary test qualities (e.g., a higher specificity at the cost of a lower sensitivity or vice versa). The specificity of the CT-Q in population B is 55%. Therefore, the choice of the cutoff values of the SR-Q and the AD-Q ensured that specificity was similar for all three questionnaires in order to facilitate a comparison of sensitivity and the positive and negative predictive values. Table 4 shows that the SR-Q with a cutoff value above five and the CT-Q have a remarkably similar and better performance than the AD-Q for this population. Figure 1 depicts a greater area under the ROC curve for the SR-Q compared with the AD-Q, although the 95% CIs overlap.

CONCLUSIONS — In the first part of the study, we demonstrate that, except for frequent thirst, the most classic symptoms (used in the AD-Q), such as tiredness, voiding large amounts of urine, or recent weight loss, are not associated with hyperglycemia per se in a 50- to 74-year-old general Caucasian population. It is not obvious why frequent thirst appears to be an exception. This association may vary between populations. We also found that the presence of symptoms that indicate cardiovascular disease or represent fitness level and musculoskeletal pain, such as pain during walking with need to slow down, and shortness of breath when walking with people of the same age, also doubles the risk for undiagnosed diabetes, regardless of any other symptom or risk factor. These associations probably point to the common soil of diabetes and cardiovascular disease, which stresses the importance of measuring glucose levels in patients presenting with cardiovascular symptoms. The classical risk factors of age, parent or sibling with diabetes, and obesity obviously contribute the most to the performance of the questionnaire. Obesity discriminates more strongly for men than for women. We used a cutoff value of 29.0 kg/m^2 for men and 28.0 kg/m^2 for women if height and weight were self-reported, as recent investigators reported an underestimation of the BMI, in particular, for obese people (23,30,31). An additional risk factor was the use of antihypertensive drugs, but in our study this association was not particularly strong for any specific group of agents (data not shown). Other

Table 3—*Prevalence of NDM in the original study population A and in the validation population B according to strata of the aggregate score*

Symptom-risk questionnaire aggregate score	Predicted prevalence of NDM (%) according to regression equation	Population A		Population B	
		NDM_A/N_A	Observed prevalence of NDM_A (%)	NDM_B/N_B	Observed prevalence of NDM_B (%)
0–3	1.2	5/636	0.8	8/363	2.2
4–6	2.1	8/570	1.4	4/158	2.5
7–9	3.7	21/520	4.0	6/136	4.4
10–12	6.4	21/313	6.7	7/70	10.0
13–15	10.4	26/196	13.2	5/32	15.6
16–18	17.2	20/91	22.0	—/12	—
19–34	28.0	9/38	23.7	2/15	13.3
Total	4.4	110/2364	4.7	32/786	4.1

Table 4—*Comparison of the performances of SR-Q, CT-Q, and the AD-Q for population B*

	SR-Q	CT-Q	AD-Q
Cutoff point*	Score > 5		Score > 3
Specificity	56 (52–59)	55 (52–58)	57 (53–61)
Sensitivity	72 (69–75)	72 (69–75)	59 (55–63)
Positive predictive value†	6.5 (4.7–8.2)	6.4 (4.6–8.1)	5.6 (4.0–7.2)
Negative predictive value†	98 (97–99)	98 (97–99)	97 (96–98)

Data are % (95% CI). *The CT-Q permits a classification of "positive" or "negative" only, whereas the SR-Q and the AD-Q have a variable cutoff value, and thus make it possible to vary test qualities. The specificity of the CT-Q in population B is 55%. Therefore, the choice of the cutoff values of the SR-Q and the AD-Q ensured that specificity was similar for all three questionnaires, in order to facilitate comparison of sensitivity and the positive and negative predictive values. †The prior probability in population B is 4.1%.

prospective studies have found β-blocking agents and/or diuretics to be independent risk factors for the development of NIDDM (27,28). The remarkable finding that regular cycling is inversely associated with NDM, far more than other physical activities, might be explained by the fact that the use of a bicycle for transportation is a specific indicator of physical activity in a 50- to 74-year-old Dutch population. This item should probably be omitted from the questionnaire if cycling is not a common habit in the population for which the questionnaire is used. The fact that for population B the area under the ROC curve with and without this question is similar, suggests that this question does not contribute much to the performance of the questionnaire. We did not find other specific indicators for physical activity to be associated with diabetes. The problem with physical activity, which also holds for abdominal obesity and far or nearsightedness, is that although this contributes to prediction of diabetes, the subject's self-assessment is not reliable and is therefore not useful in a risk-assessment questionnaire.

The second part of the study shows the empirically tested yield of screening for undiagnosed NIDDM based on a questionnaire. When applying the SR-Q with, for example, a cutoff value of >5 in a 45- to 74-year-old Caucasian population, 45% of the subjects will need to undergo further blood glucose testing to identify 72% with undiagnosed diabetes. We found that the same applied to the CT-Q. Contrary to the CT-Q, the new SR-Q allows for different cutoff values, depending on the decision whether or not to carry out further testing.

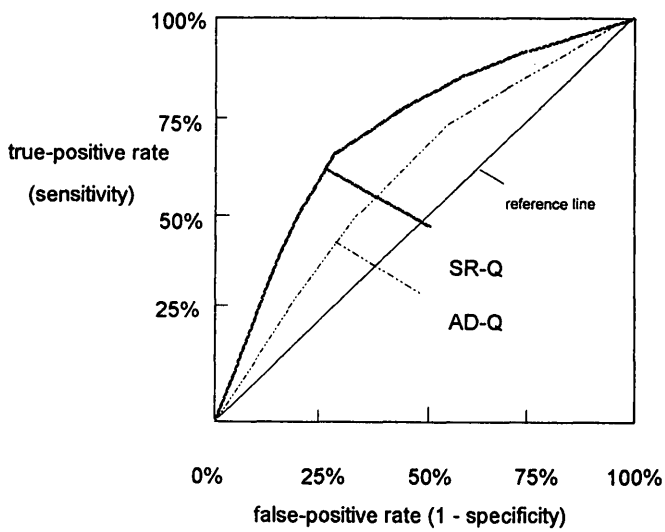

Figure 1—*Area under the ROC curves and 95% CI (population B): ROC curves of the SR-Q, 0.69 (0.60–0.79) and AD-Q, 0.62 (0.50–0.73).*

If, for example, it was decided to offer 14% of the population further blood glucose testing after preselection with the SR-Q, the cutoff value should be 10, resulting in identification of 44% of undiagnosed diabetic subjects. An extra step can be added to this approach, by measuring a random blood glucose value or a blood glucose value ~2 h after a carbohydrate-enriched breakfast in the selected subjects, before establishing a final diagnosis.

By using two different populations, one for the development and the other for the validation of our SR-Q questionnaire, we have provided concrete insight into the performance of the questionnaire. If the data from only population A were presented, the results would have been much more impressive, but also less meaningful. The better performance of the SR-Q in population A than in population B is probably a result of small differences that always exist between populations, and the fact that the logistic regression model was built with the data of population A. The size of the sample of population B determines the precision of the estimated performance and does not per se contribute to a difference in performances. The lower response rate in population B (53%) than in population A (72%) could contribute to a selection of more willing participants because only one invitation was mailed to each subject. However, it is likely that such selection bias also occurs in a screening program. The SR-Q has the definite advantage of enabling the respondents to assess their own risk for undiagnosed diabetes, even more so if the questionnaire is supplemented by a table translating the aggregate score into the probability of having diabetes (Table 3). We conclude that this newly developed questionnaire, SR-Q, is a useful screening tool for NIDDM in general practice.

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