Type 2 Diabetes in Older Well-Functioning People: Who Is Undiagnosed?

Data from the Health, Aging, and Body Composition Study

LONNEKE V. FRANSE, MSC[1,2]
MAURO DI BARI, MD, PHD[1,3]
RON I. SHORR, MD, MS[1]
HELAINE E. RESNICK, PHD[4]
JACQUES T. M. VAN EIJK, PHD[5]
DOUG C. BAUER, MD[6]
ANNE B. NEWMAN, MD, PHD[7]
MARCO PAHOR, MD[8]
FOR THE HEALTH, AGING, AND BODY COMPOSITION STUDY GROUP

OBJECTIVE — To assess, in an older population, the prevalence of diagnosed and undiagnosed diabetes, the number needed to screen (NNTS) to identify one individual with undiagnosed diabetes, and factors associated with undiagnosed diabetes.

RESEARCH DESIGN AND METHODS — Socioeconomic and health-related factors were assessed at the baseline examination of the Health, Aging, and Body Composition (Health ABC) Study, a cohort of 3,075 well-functioning people aged 70–79 years living in Memphis, Tennessee and Pittsburgh, Pennsylvania (42% blacks and 48% men). Diabetes was defined according to the 1985 World Health Organization criteria (fasting glucose ≥7.8 mmol/l or 2-h glucose ≥11.1 mmol/l) and the 1997 American Diabetes Association criteria (fasting glucose ≥7.0 mmol/l).

RESULTS — The prevalence of diagnosed and undiagnosed diabetes was 15.6 and 8.0%, respectively, among all participants (NNTS 10.6), 13.9 and 9.1% among white men (NNTS 9.5), 7.8 and 7.4% among white women (NNTS 12.4), 22.7 and 9.1% among black men (NNTS 8.5), and 21.6 and 6.2% among black women (NNTS 12.6). In multivariate analyses, compared with individuals without diabetes, individuals with undiagnosed diabetes were more likely to be men and were more likely to have a history of hypertension, higher BMI, and larger waist circumference. NNTS was lowest in men (9.1), individuals with hypertension (8.7), individuals in the highest BMI quartile (6.9), and individuals in the largest waist circumference quartile (6.8).

CONCLUSIONS — In approximately one-third of all older people with diabetes, the condition remains undiagnosed. Screening for diabetes may be more efficient among men and individuals with hypertension, high BMI, and large waist circumference.

Diabetes Care 24:2065–2070, 2001

From the [1]Department of Preventive Medicine, University of Tennessee, Memphis, Tennessee; the [2]Institute for Research in Extramural Medicine (EMGO), Vrije Universiteit, Amsterdam, the Netherlands; the [3]Department of Gerontology and Geriatrics, University of Florence and 'Careggi' Hospital, Florence, Italy; [4]MedStar Research Institute, Washington, DC; the [5]Department of Medical Sociology, University of Maastricht, Maastricht, the Netherlands; the [6]Prevention Sciences Group, University of California, San Francisco, California; the [7]Department of Medicine, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania; and the [8]Sticht Center on Aging, Department of Internal Medicine, Wake Forest University School of Medicine, Winston-Salem, North Carolina.

Address correspondence and reprint requests to Lonneke Franse, MSc, Comprehensive Cancer Center South, P.O. Box 231, 5600 AE, Eindhoven, the Netherlands. E-mail: l.vd.poll@ikz.nl.

Received for publication 16 May 2001 and accepted in revised form 21 August 2001.

Abbreviations: ADA, American Diabetes Association; Health ABC, Health, Aging, and Body Composition; NHANES III, Third National Health and Nutrition Examination Survey; NNTS, number needed to screen; OGTT, oral glucose tolerance test; WHO, World Health Organization.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Diabetes and its complications are significant causes of morbidity and mortality in the U.S. (1,2). Although the prevalence of hypertension (3), hypercholesterolemia (4), and incidence of and mortality from heart disease (5,6) and stroke (7) are markedly declining, the prevalence of diabetes remains high and is expected to increase further, especially in the older population (8). According to the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III), the prevalence of physician-diagnosed and undiagnosed diabetes (based on the 1985 World Health Organization [WHO] criteria) in people aged 60–74 years is 12.6 and 10.8%, respectively (9), resulting in a total prevalence of 23.4%.

Many individuals with diabetes remain unidentified, untreated, and at risk for complications. Since the American Diabetes Association (ADA) introduced new diagnostic criteria for type 2 diabetes (10), the exclusive use of fasting glucose to define glucose tolerance has been debated. It has been suggested that by applying the new diagnostic criteria, diabetes may remain undiagnosed in even more individuals (11). Undiagnosed diabetes may have substantial public health implications (12–15), but little is known about the risk factors for undiagnosed diabetes. The objectives of this study were to determine the prevalence of undiagnosed diabetes in a large population of older adults, the number needed to screen to identify one undiagnosed person, and the characteristics of the individuals that might be most effectively targeted with screening programs.

RESEARCH DESIGN AND METHODS

— Diabetes was assessed at the baseline examination of the Health, Aging, and Body Composition (Health ABC) Study. Health ABC is a 7-year prospective study of changes in body composition, weight-related health conditions, and incident functional limitation. The study population consists of 3,075 individuals aged 70–79 years, 42% of whom are black and 48% of whom are men. Participants were identified from the Medicare-eligible population residing in the Memphis, Tennessee and Pittsburgh, Pennsylvania area. To be eligible, participants had to report no difficulty in walking for 0.25 mile (400 m), walking up 10 steps, getting in and out of bed or chairs, bathing or showering, dressing, or eating and must report no need of using a cane, walker, crutches, or other special equipment to get around. All procedures related to Health ABC received Institutional Review Board approval from the participating institutions.

Measures

The baseline home visit questionnaire, administered between April 1997 and May 1998, assessed demographic and socioeconomic characteristics, health behaviors, and health status, including medical history. The subsequent baseline clinic visit, conducted within 2 weeks of the interview, included a fasting glucose measurement and a 75-g oral glucose tolerance test (OGTT) performed after an 8-h overnight fast.

Diabetic status was defined by self-reported response to the question "Has a doctor ever told you that you have diabetes or sugar diabetes?" (excluding diabetes that only occurred during pregnancy). If so, participants were asked if they currently used insulin or hypoglycemic agents. Except for those who reported taking insulin or oral hypoglycemic agents, participants underwent an OGTT. Participants who did not report prior diagnosis of diabetes were classified according to the 1985 WHO criteria: fasting glucose concentration ≥7.8 mmol/l (≥140 mg/dl) or a 2-h glucose concentration of ≥11.1 mmol/l (≥200 mg/dl). For additional analyses, participants who did not report prior diagnosis of diabetes were also classified according to the 1997 ADA criteria: fasting glucose concentration ≥7.0 mmol/l (≥126 mg/dl). Participants were classified as undiagnosed if they reported no prior diagnosis of diabetes but met the WHO or ADA criteria for diabetes.

We used both WHO criteria and 1997 ADA criteria because at the time of most baseline interviews, the ADA criteria were just being disseminated. To compare our results with older and current reports, we applied both WHO and ADA criteria in analyses. For both classifications, we included only participants who had both fasting and 2-h glucose measurements. Of the 3,075 participants in Health ABC, 125 were missing either fasting glucose or the OGTT and were excluded from this analysis, leaving an analysis sample of 2,950 participants (95.9% of the cohort).

The demographic and socioeconomic characteristics assessed included participants' self-reported age, sex, race, years of education, and annual family income. Health behavior included self-reported current and past smoking and alcohol use in the past 12 months. Health service use involved measures of having a usual source of care ("Do you have a doctor or place that you usually go to for health care or advice about your health care?"), having a health insurance plan in addition to Medicare, and hospitalization in the year before the baseline interview.

Health conditions were assessed based on self-reported history of cancer, hypertension, and cardiovascular disease (myocardial infarction, angina pectoris, congestive heart failure, intermittent claudication, transient ischemic attack, stroke, and rheumatic heart disease) or any medical procedure in heart, neck, or blood vessels, such as an angioplasty or bypass surgery. Height (mm) was measured twice by a Harpenden stadiometer (Holtain, Crosswell, U.K.) and weight was measured by a standard balance-beam scale to the nearest 0.1 kg. Using the mean of the two height measurements, BMI (kg/m^2) was calculated as weight divided by the square of height. Waist circumference was measured in centimeters.

For the analyses of each potential predictor, we excluded participants who had missing information on that particular variable. Except for annual family income (410 participants [14%] were missing this information), 0–20 participants (<1%) were missing information for all variables.

Analyses

Statistical analyses were performed using the SPSS version 8.0 for Windows software package (SPSS, Chicago, IL) (16). Analysis of variance for multiple dependent variables by one or more factor variables was used to assess differences in fasting glucose and HbA_{1c} between diagnosed and undiagnosed diabetic participants. A χ^2 test was used to assess differences in prevalence of diabetes between different race and sex groups. Logistic regression analysis was used to assess associations between potential predictors and (un)diagnosed diabetes (versus no diabetes), after adjusting for age, sex, and race. Risk factors for diagnosed diabetes are presented so that direct comparison with risk factors for undiagnosed diabetes is possible. To calculate the number needed to screen (NNTS) to identify one individual with undiagnosed diabetes in each individual subgroup, the number of undiagnosed plus nondiabetic subjects was divided by the number of undiagnosed diabetic subjects.

RESULTS — The prevalence of diabetes, using the 1980–1985 WHO criteria, was highest in black men (31.8%) compared with white men and women ($P < 0.001$ versus white men and women) (Table 1). White women had the lowest prevalence of diabetes (15.3%; $P < 0.001$ versus other subgroups), which was almost half the prevalence in black women (27.8%). The prevalence of undiagnosed diabetes was not significantly different in white women (7.4%) compared with black women (6.2%). The prevalence of undiagnosed diabetes was similar among white and black men (9.1%). Additional analyses, using the fasting 1997 ADA criteria, revealed that the total prevalence of diabetes was 4–6% lower than the 1985 WHO criteria (Table 1). The prevalence of undiagnosed diabetes was again higher in men (white men 5.1%, black men 5.3%) than in women (white women 1.5%, black women 2.8%).

The association of age, race, sex, and site with diagnosed and undiagnosed diabetes (according to the 1985 WHO criteria) compared with no diabetes was assessed in a multivariate logistic regression model. Compared with women, men had a higher risk of both diagnosed and undiagnosed diabetes. Black race was strongly and significantly associated with a higher risk of diagnosed diabetes, independent of age and sex (Table 2). Race was not significantly associated with undiagnosed diabetes.

In subsequent multivariate logistic regression analyses adjusted for age, race, and sex, the risk of having diagnosed diabetes decreased with increasing years of education, increasing income levels, and increasing use of alcohol (Table 3). The

Table 1—*Prevalence of diagnosed diabetes, undiagnosed diabetes, and NNTS according to 1985 WHO criteria and 1997 ADA criteria, stratified by race and sex*

	Total	White (n = 1,732)		Black (n = 1,218)	
	(n = 2,950)	Men (n = 913)	Women (n = 819)	Men (n = 528)	Women (n = 690)
Diagnosed diabetes†	460 (15.6)	127 (13.9)	64 (7.8)	120 (22.7)	149 (21.6)
1985 WHO criteria					
Undiagnosed diabetes‡	235 (8.0)	83 (9.1)	61 (7.4)	48 (9.1)	43 (6.2)
Total diabetes prevalence*	695 (23.6)	210 (23.0)	125 (15.3)	168 (31.8)	192 (27.6)
NNTS§	10.6	9.5	12.4	8.5‖	12.6
1997 ADA criteria					
Undiagnosed diabetes‡	106 (3.6)	47 (5.1)	12 (1.5)	28 (5.3)	19 (2.8)
Total diabetes prevalence*	566 (19.2)	174 (19.1)	76 (9.3)	148 (28.0)	168 (24.3)
NNTS	23.5	16.7	62.9	14.6‖	28.5¶

Data are n (%). *Undiagnosed plus diagnosed diabetes; †participants who reported prior diagnosis by a physician; ‡participants who met diabetes criteria but responded "no" to the question "Has a doctor ever told you that you have diabetes?"; §NNTS smaller in all subgroups compared with ADA criteria; ‖$P < 0.05$ versus white and black women; ¶$P < 0.05$ versus white women.

risk of having diagnosed diabetes was positively associated with access to a doctor for health care, hospitalization during the last year, history of hypertension, history of cardiovascular disease, and increasing quartiles of BMI and waist circumference. The risk of having undiagnosed diabetes was positively associated with a history of hypertension and increasing BMI and waist circumference quartiles. In a multivariate model including age, race, sex, history of hypertension, BMI, and circumference, only male sex (odds ratio 1.4, 95% CI 1.1–1.9) and history of hypertension (1.5, 1.1–2.0) were significantly associated with undiagnosed diabetes.

The results were virtually unchanged when the same multivariate logistic regression analyses were performed using the 1997 ADA fasting glucose criteria (data not shown). Applying these criteria, men were at even higher risk for having undiagnosed diabetes (odds ratio 2.8, 95% CI 1.8–4.3) than women. In addition, using the 1985 WHO fasting criteria (fasting glucose ≥7.8 mmol/l) without using the OGTT, the same risk factors for undiagnosed diabetes were again identified. The prevalence of diabetes was 17.5%.

Comparing race and sex groups, the NNTS to identify one person with undiagnosed diabetes was lowest in black men (8.5) and significantly lower than the NNTS in black women (12.6; $P = 0.02$) and white women (12.4; $P = 0.03$) (Table 1). Furthermore, small NNTS were found among people with a history of hypertension (8.7) and those in the highest quartiles of BMI (6.9) or waist circumference (6.8). Consequently, combinations of these risk factors result in lower NNTS (Fig. 1). Because the prevalence of undiagnosed diabetes was 4–6% lower using the 1997 ADA criteria, the calculated NNTS was significantly higher in all subgroups (Table 1).

CONCLUSIONS — The present study shows that diabetes remains undiagnosed in approximately one-third of all older individuals. In this study of healthier older adults, men, individuals with a history of hypertension, and individuals with high BMI and large waist circumference were at highest risk of having undiagnosed diabetes. Screening for diabetes may be more efficient among these subgroups, especially among individuals with combinations of these risk factors, in which the NNTS to identify one undiagnosed diabetic was lowest.

The prevalence of diabetes in this study was similar to estimates reported in NHANES III (9). Overall, American minorities were more frequently affected by diabetes, but the racial difference declined in older age groups. Indeed, 22.7%

Table 2—*Risk of having diagnosed or undiagnosed diabetes (according to 1985 WHO criteria) compared with no diabetes*

	n (%)	Odds ratio (95% CI) of having diagnosed type 2 diabetes	Odds ratio (95% CI) of having undiagnosed type 2 diabetes	NNTS
Age				
≤73 years (median age)*	1,538 (52.1)	1.0	1.0	11.1
>73 years	1,412 (47.9)	1.0 (0.8–1.3)	1.1 (0.8–1.4)	10.1
Sex				
Female†	1,509 (51.2)	1.0	1.0	12.5¶
Male	1,441 (48.8)	1.4 (1.2–1.7)§	1.4 (1.1–1.9)§	9.1
Race				
Black‡	1,218 (41.3)	1.0	1.0	10.4
White	1,732 (58.7)	0.4 (0.3–0.5)‖	0.9 (0.7–1.2)	10.7

*Adjusted for sex and race, †adjusted for age and race. ‡adjusted for age and sex; §$P < 0.05$; ‖$P < 0.001$; ¶$P < 0.05$ compared with male sex.

Table 3—*Risk of having diagnosed or undiagnosed diabetes (according to 1985 WHO criteria) compared with no diabetes*

	n (%)	Odds ratio (95% CI) of having diagnosed type 2 diabetes*	Odds ratio (95% CI) of having undiagnosed type 2 diabetes*	NNTS
Socioeconomic				
Education (years)				
0–11	711 (24.1)	1.0	1.0	9.6
12–14	1,000 (33.9)	0.9 (0.7–1.2)	1.1 (0.7–1.5)	9.6
≥15	1,232 (41.8)	0.7 (0.5–0.9)†	0.8 (0.5–1.1)	12.4
		P trend = 0.01	*P* trend = 0.08	
Annual family Income ($)				
<10,000	347 (11.8)	1.0	1.0	11.4
10,000–25,000	1,008 (34.2)	0.7 (0.5–1.0)	1.1 (0.7–1.8)	10.3
25,000–50,000	779 (26.4)	0.7 (0.5–0.9)†	1.1 (0.6–1.9)	10.3
>50,000	406 (13.8)	0.5 (0.3–0.7)†	1.0 (0.6–1.9)	10.4
		P trend = 0.002	*P* trend = 0.99	
Health behavior				
Smoking				
Never	1,294 (43.9)	1.0	1.0	11.7
Ever smoked	1,358 (46.0)	1.1 (0.9–1.4)	1.2 (0.9–1.6)	9.2†
Currently smoking	293 (9.9)	0.7 (0.5–1.1)	0.7 (0.4–1.2)	14.7
Alcohol use in past 12 months				
Never	1,482 (50.2)	1.0	1.0	11.3
Occasional	612 (20.7)	0.5 (0.4–0.7)‡	1.1 (0.8–1.6)	10.2
1–7 drinks/week	632 (21.4)	0.4 (0.3–0.5)‡	1.0 (0.7–1.5)	10.7
≥8 drinks/week	213 (7.2)	0.2 (0.1–0.4)‡	1.3 (0.8–2.1)	8.4
		P trend < 0.001	*P* trend = 0.46	
Health service use				
Doctor to usually go to				
No	167 (5.7)	1.0	1.0	8.1
Yes	2,775 (94.1)	7.3 (3.0–18.0)‡	0.7 (0.5–1.2)	10.8
Health insurance plan in addition to Medicare				
No	560 (19.0)	1.0	1.0	9.6
Yes	2,370 (80.3)	1.0 (0.8–1.3)	0.9 (0.6–1.3)	10.9
Hospitalization last year				
No	2,505 (84.9)	1.0	1.0	10.9
Yes	439 (14.9)	1.5 (1.1–1.9)†	1.2 (0.8–1.7)	9.2
Physical health conditions				
History of cancer				
No	2,381 (80.7)	1.0	1.0	10.9
Yes	562 (19.1)	0.9 (0.7–1.2)	1.2 (0.8–1.6)	9.4
History of hypertension				
No	1,419 (48.1)	1.0	1.0	13.4
Yes	1,508 (51.1)	2.2 (1.8–2.8)‡	1.7 (1.3–2.2)‡	8.7§
History of cardiovascular disease/procedures				
No	2,023 (68.6)	1.0	1.0	11.4
Yes	927 (31.4)	1.5 (1.2–1.8)‡	1.2 (0.9–1.7)	9.0
BMI (kg/m^2)				
<24.1¶	734 (24.9)	1.0	1.0	15.6
24.1–26.8	738 (25.0)	1.5 (1.0–2.0)†	1.0 (0.7–1.6)	14.6
26.9–30.0	734 (24.9)	2.0 (1.4–2.8)‡	1.7 (1.1–2.6)†	9.3
≥30.1	744 (25.2)	3.2 (2.3–4.3)†	2.6 (1.7–3.8)‡	6.9‖
		P trend < 0.001	*P* trend < 0.001	
Waist circumference (cm)				
<91.8¶	736 (24.9)	1.0	1.0	17.3
91.8–99.3	743 (25.2)	1.8 (1.3–2.5)‡	1.3 (0.8–2.0)	13.4
99.4–107.1	731 (24.8)	2.4 (2.7–3.3)‡	1.9 (1.2–2.9)†	9.2
≥107.2	734 (24.9)	3.8 (2.8–5.2)‡	2.7 (1.8–4.1)‡	6.8‖
		P trend < 0.001	*P* trend < 0.001	

*Adjusted for age, sex, and race; †*P* < 0.05; ‡*P* < 0.001; §*P* < 0.05; ‖*P* < 0.05 compared with first and second quartile; ¶quartiles.

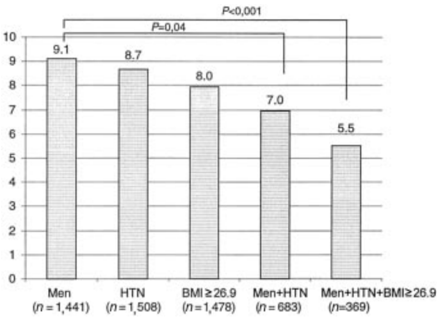

Figure 1—*NNTS among different subgroups. HTN, hypertension.*

of white men, 22.1% of white women, 26.5% of black men, and 31.7% of black women aged 60–74 years were diabetic in NHANES III, using WHO criteria. The percentage of undiagnosed diabetes in this older population was 11.8% in white men, 10.4% in white women, 9.7% in black men, and 7.8% in black women.

The higher prevalence of diabetes found when applying WHO compared with the fasting glucose ADA criteria may be explained by the higher sensitivity of the glucose tolerance test in older individuals (11), particularly in women, who tend to have higher post challenge glucose levels than men (17). Furthermore, American men generally have higher fasting glucose levels than women (9). Higher post challenge glucose levels in combination with lower fasting glucose levels could also explain our finding that women, compared with men, were at significantly lower risk for undiagnosed diabetes when we used the ADA or WHO fasting criteria. Longitudinal studies showed that the new fasting ADA criteria were less predictive than the WHO criteria for the burden of cardiovascular disease (1) and mortality (2) associated with abnormal glucose, especially in the elderly. Therefore, a screening program based only on fasting glucose would miss a large proportion of older people with important metabolic disorders.

In contrast with NHANES III (9), we did not find an association between age and the risk of undiagnosed or diagnosed diabetes, probably because of the narrow age range (70–79 years) in our study. The higher risk of undiagnosed diabetes in individuals with hypertension, high BMI, and large waist circumference probably point to the common ground of diabetes and cardiovascular disease (18) and confirms the importance of monitoring glucose levels in people with cardiovascular risk factors.

In subgroups with a low risk of diagnosed diabetes, such as whites, those with higher income, and more years of education, the risk of having undiagnosed diabetes was not significantly lower compared with blacks, individuals with lower income, and individuals with fewer years of education. These subgroups may be characterized by "milder" types of diabetes and may have a higher probability of remaining undiagnosed. The severity of diabetes, as measured by mean fasting glucose and HbA_{1c}, was less in individuals undiagnosed according to the WHO criteria (125 mg/dl and 6.9%, respectively) compared with individuals with diagnosed diabetes (155 mg/dl and 8.0%, respectively; $P < 0.001$ when comparing both groups). These people are probably less likely to develop complications compared with those with higher glucose levels who are aware of their condition. Another explanation could be that certain subgroups are considered to be at low risk of diabetes and, therefore, are less frequently evaluated. Analyses of NHANES II (1976–1980) showed that screening rates increased with increasing number of risk factors for diabetes, but even among those with three risk factors, only 38.6% reported to be evaluated in the year before the study (19). Longitudinal cost-effectiveness analyses are necessary to fully assess the benefits of early detection and treatment in different subgroups (20).

The fact that the risk of undiagnosed diabetes was similar in black and white individuals could also suggest that the message about increased risk of diabetes is reaching some parts of the black community (at least this cohort) and their health care providers. However, we do not know from our data whether those with diagnosed diabetes are getting adequate treatment. In addition, our sample may not be representative of black people in general.

Several limitations of our study must be acknowledged. First, the cross-sectional study design makes it difficult to draw inferences about causal pathways. Second, fasting glucose and 2-h glucose were only measured once. Because the diagnostic criteria of WHO and ADA both require two independent fasting samples to diagnose diabetes, this could lead to misclassification of some individuals. However, it is unlikely that this would have changed the set of predictors of undiagnosed diabetes that we identified, because they were virtually the same when using WHO, ADA, or WHO-exclusive fasting criteria. Third, because 14% of the participants were missing information on annual family income, we must be careful with the interpretation of income as a risk factor for (un)diagnosed diabetes. Last, this study population represents the well-functioning fraction of the older population, in an equally balanced racial design that may not be a representative sample of the overall U.S. population aged 70–79 years. The selection of relatively healthier people might have resulted in a lower prevalence of diabetes. Unlike NHANES, Health ABC was not intended to reflect the Medicare population of the U.S., and extrapolation of our findings to all elderly individuals in the U.S. should be done with caution.

Public health implications

Our findings have potentially relevant public health implications. It is estimated that there will be a 42% increase in prevalence of diabetes among adults in developed countries by the year 2025; the U.S. will be one of the three countries with the largest number of people with the disease (8). In the future, this increase could offset the benefits of better control of hypertension, hypercholesterolemia, and reduction of smoking on the risk of cardiovascular disease in the community, especially if one-third of the individuals with the disease remain undiagnosed. In the clinical recommendations of 2001, the ADA states that, based on the current lack of scientific evidence, community screening for diabetes, even in high-risk populations, is not recommended. Nevertheless, there is sufficient indirect evidence to justify opportunistic screening in a clinical setting of individuals at high risk (21). The NNTS found in our study suggests that screening for diabetes may be more efficient among men and individuals with hypertension, high BMI, and large waist circumference.

Acknowledgments— This study was supported by the National Institute on Aging Contract nos. N01-AG-6-2,106; N01-AG-6-2,102; and N01-AG-6-2,103. Marco Pahor was supported by the Claude D. Pepper Older

Americans Independence Center Grant no. NIA P60 AG10484

References

1. Barzilay JI, Spiekerman CF, Wahl PW, Kuller LH, Cushman M, Furberg CD, Dobs A, Polak JF, Savage PJ: Cardiovascular disease in older adults with glucose disorders: comparison of American Diabetes Association criteria for diabetes mellitus with WHO criteria. *Lancet* 354:622–625, 1999
2. The DECODE study group: European Diabetes Epidemiology Group: Glucose tolerance and mortality: comparison of WHO and American Diabetes Association diagnostic criteria. Diabetes epidemiology: collaborative analysis of diagnostic criteria in Europe. *Lancet* 354:617–621, 1999
3. Burt VL, Culter JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Rocella EJ: Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population: data from the health examination surveys, 1960 to 1991. *Hypertension* 26:60–69, 1995
4. Johnson CL, Rifkind BM, Sempos CT, Carroll MD, Bachorik PS, Briefel RR, Gordon DJ, Burt VL, Brown CD, Lippel K: Declining serum total cholesterol levels among US adults: the National Health and Nutrition Examination Surveys. *JAMA* 269:3002–3008, 1993
5. Pell S, Fayerweather WE: Trends in the incidence of myocardial infarction and in associated mortality and morbidity in a large employed population, 1957–1983. *N Engl J Med* 312:1005–1011, 1985
6. Sytkowski PA, Kannel WB, D'Agostino RB: Changes in risk factors and the decline in mortality from cardiovascular disease: the Framingham Heart Study. *N Engl J Med* 322:1635–1641, 1990
7. McGovern PG, Shahar E, Sprafka JM, Pankow JS: The role of stroke attack rate and case fatality in the decline of stroke mortality: the Minnesota Heart Survey. *Ann Epidemiol* 3:483–487, 1993
8. King H, Aubert RE, Herman WH: Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 21:1414–1431, 1998
9. Harris MI, Flegal KM, Cowie CC, Eberhardt MS, Goldstein DE, Little RR, Wiedmeyer H-M, Byrd-Holt DD: Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults: the Third National Health and Nutrition Examination Survey, 1988–1994. *Diabetes Care* 21:518–524, 1998
10. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 20:1183–1197, 1997
11. Wahl PW, Savage PJ, Psaty BM, Orchard TJ, Robbins JA, Tracy RP: Diabetes in older adults: comparison of 1997 American Diabetes Association classification of diabetes mellitus with 1985 WHO classification. *Lancet* 352:1012–1015, 1998
12. Beks PJ, Mackaay AJ, de Neeling JN, de Vries H, Bouter LM, Heine RJ: Peripheral arterial disease in relation to glycaemic level in an elderly Caucasian population: the Hoorn study. *Diabetologia* 38:86–96, 1995
13. Curb JD, Rodriguez BL, Burchfiel CM, Abbott RD, Chiu D, Yano K: Sudden death, impaired glucose tolerance, and diabetes in Japanese American men. *Circulation* 91:2591–2595, 1995
14. Wilson PW, Cupples LA, Kannel WB: Is hyperglycemia associated with cardiovascular disease? The Framingham Study. *Am Heart J* 121:586–590, 1991
15. Wingard DL, Barrett-Connor EL, Scheidt-Nave C, McPhillips JB: Prevalence of cardiovascular and renal complications in older adults with normal or impaired glucose tolerance or NIDDM: a population-based study. *Diabetes Care* 16:1022–1025, 1993
16. SPSS: *Statistical Package for the Social Sciences Advanced Statistics Reference Guide*. Chicago, IL, SPSS, 1997
17. Barrett-Connor E, Ferrara A: Isolated postchallenge hyperglycemia and the risk of fatal cardiovascular disease in older women and men: the Rancho Bernardo Study. *Diabetes Care* 21:1236–1239, 1998
18. Reaven GM: Banting lecture 1988: role of insulin resistance in human disease. *Diabetes* 37:1595–1607, 1988
19. Cowie CC, Harris MI, Eberhardt MS: Frequency and determinants of screening for diabetes in the U.S. *Diabetes Care* 17:1158–1163, 1994
20. CDC Diabetes Cost-Effectiveness Study Group, Centers for Disease Control and Prevention: The cost-effectiveness of screening for type 2 diabetes. *JAMA* 280:1757–1763, 1998
21. American Diabetes Association: Screening for diabetes: clinical practice recommendations 2001. *Diabetes Care* 24 (Suppl. 1):S21–S24, 2001