Multicenter Study of the Prevalence of Diabetes Mellitus and Impaired Glucose Tolerance in the Urban Brazilian Population Aged 30–69 Yr

DOMINGOS A. MALERBI, MD, PHD
LAERCIO J. FRANCO, MD, PHD
THE BRAZILIAN COOPERATIVE GROUP ON THE STUDY OF DIABETES PREVALENCE

OBJECTIVE — To assess the prevalence of diabetes and IGT in the urban adult Brazilian population.

RESEARCH DESIGN AND METHODS — We used a two-stage, multicenter, cross-sectional survey in a random sample of 21,847 individuals aged 30–69 yr from nine large cities. Subjects were first screened by FCG. All positive screenees (FCG ≥ 5.6 mM/L) and every sixth consecutive negative screenee were administered a 75 g OGTT and classified as diabetic, IGT, or normal (nondiabetic) according to WHO recommendations. OGTT findings from the negative screenees were extrapolated to all negative screenees after adjustments for potential biases.

RESULTS — The overall rates were 7.6 and 7.8% for diabetes and IGT, respectively. Men (7.5%) and women (7.6%) had similar rates of diabetes. Similar rates resulted with whites (7.8%) and nonwhites (7.3%). Diabetes prevalence increased from 2.7% in the 30–39-yr age-group to 17.4% in the 60–69-yr age-group. Diabetes was more prevalent among less educated people, but this difference disappeared after adjusting for age. Family history of diabetes was associated with a twofold increase in diabetes prevalence (12.5 vs. 5.8%); the same increase occurred with obesity (11.6 vs. 5.2%). Undiagnosed diabetes accounted for 46% of the total prevalence. Among previously diagnosed cases, 22.3% were not under treatment, 7.9% were on insulin, 40.7% were on oral agents, and 29.1% were on dietary treatment only. Self-reported diabetes prevalence was 0.1, 3.2, and 11.6% in the age groups <30, 30–69, and >70 yr, respectively.

CONCLUSIONS — The prevalence of diabetes in Brazil is comparable with that of more developed countries, where it is considered a major health problem.

FROM THE LABORATORY OF HUMAN NUTRITION AND METABOLIC DISEASES (LIM-25), DIVISION OF ENDOCRINOLOGY, UNIVERSITY OF SAO PAULO MEDICAL SCHOOL AND THE DEPARTMENT OF PREVENTIVE MEDICINE, ESCOLA PAULISTA DE MEDICINA, SAO PAULO, BRAZIL.

ADDRESS CORRESPONDENCE AND REPRINT REQUESTS TO DOMINGOS A. MALERBI, MD, PHD, SERVIÇO DE ENDOCRINOLOGIA, HOSPITAL DAS CLINICAS–FMUSP, CAIXA POSTAL 8091, CEP 01000, SAO PAULO-SP, BRAZIL.

RECEIVED FOR PUBLICATION 19 FEBRUARY 1992 AND ACCEPTED IN REVISED FORM 2 JULY 1992.

IGT, IMPAIRED GLUCOSE TOLERANCE; FCG, FASTING CAPILLARY GLUCOSE; OGTT, ORAL GLUCOSE TOLERANCE TEST; WHO, WORLD HEALTH ORGANIZATION; BMI, BODY MASS INDEX; TYPE II DIABETES, NON-INSULIN-DEPENDENT DIABETES MELLITUS; TYPE I DIABETES, INSULIN-DEPENDENT DIABETES MELLITUS.

Brazil is a tropical country with an area of 8.5 million km^2 (almost half of South America) and a population estimated in 1987 at ~140 million. The country has undergone profound and very rapid economic and political changes in the last decades, which induced equally profound demographic and epidemiological changes. Internal migration was massive, the proportion of the population living in urban areas having increased from 33 to 66% between 1960 and 1980. Infant mortality rates dropped by >40% between 1965 and 1985, and death rates due to infectious and parasitic diseases declined by ~70% between 1960 and 1980.

Although these old health problems have receded, new ones have arisen. The proportion of mortality attributable to noncommunicable diseases rose from 33% in 1960 to >50% in 1986. Currently, noncommunicable diseases account for >33% of hospital admissions not associated with pregnancy and are an increasingly dominant cause of demand for health services (1). Because these diseases generally are more costly to treat, this shift will create a substantial increase in the cost of medical care.

Diabetes mellitus, as an underlying cause of death, is among the 10 major causes of mortality in Brazil. In Sao Paulo, the largest city in the country, diabetes as an underlying or associated cause of death for individuals aged 15–74 yr accounted for 10.8% of the total deaths during the period 1974–1975 (2). Data about the prevalence of diabetes in Brazilians are scarce and very limited. Published rates range from 2.7 to 2.9% of the population, but these were derived either from nonrepresentative samples (3,4) or from self-reports (5). However, in recent years, there has been a growing concern that diabetes is becoming more common, particularly in the more urbanized and industrialized segments of the population (6).

Given the changing age structure and health patterns of the population,

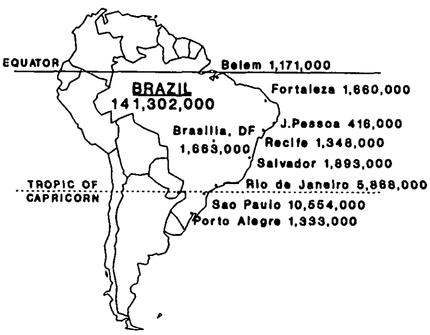

Figure 1—*Geographical distribution of the participating centers and their estimated population for 1987.*

what public health priority should be given now and in the coming years to diabetes? To address this question, and to fill the lack of information about population-based data on the prevalence and associated variables of diabetes, the Brazilian Multicenter Study on the Prevalence of Diabetes was conducted. The study was performed in a representative sample of the population of nine Brazilian cities during 1986 to 1988. It is the first population-based survey in Brazil that used WHO criteria for the diagnosis of diabetes, thus allowing international comparisons.

RESEARCH DESIGN AND METHODS— This study was a cross-sectional home survey conducted from November 1986 to July 1988 in a random sample of 21,847 individuals aged 30–69 yr in nine Brazilian cities. Figure 1 depicts the geographical distribution of the nine cities. Based on self-classification of skin color, the racial distribution of the Brazilian population in the 1980 census (7) was 54.2% whites, 44.8% blacks, 0.6% Asians, and 0.2% South American Indians.

Census tracts in each city were selected based on their representativeness toward the entire city population with regard to sex, age, and socioeconomic status. The 1980 Brazilian census (7) provided the basic demographic data to characterize the population and to assess representativeness of the eligible samples. Within each census tract, households were randomly selected.

Residents in the households were informed about the survey through a letter from the local coordinators and were visited by an interviewer a few days thereafter. All household residents aged 30–69 yr, excluding those pregnant, were invited to participate in the survey and were scheduled for the screening procedures. To minimize the possibility of a recruitment bias for family clustering of diabetes or its risk factors, the sample size was increased by selecting ~1500 households in each city. Within the sampling conditions of this study, the number of eligible subjects living in these households was twice that necessary for a standard error of 1% (8).

During the first visit, information also was obtained about the presence of diabetes among people in the household. Subjects were asked to fast overnight before the screening procedures. A few days later, the household was visited by the study team. A questionnaire was administered to characterize subjects with regard to sex, color, age, place of birth, educational level, occupation, health conditions, and personal or family history of diabetes. The fasting condition was verified by interview, and FCG was measured by glucose-oxidase strips read in a reflectance meter (Dextrostix/Glucometer system, Miles Laboratories, Inc., Elkhart, IN).

Subjects with previously diagnosed diabetes using insulin, or with a history of glycemia ≥11.1 mM, or with FCG ≥11.1 mM at screening and subjects without a history of diabetes who had FCG ≥11.1 mM at screening were considered to have diabetes. Nondiabetic subjects with an FCG of 5.6–11.0 mM, those with a history of diabetes not confirmed by the above criteria, and every sixth consecutive negative screenee (FCG <5.6 mM) were scheduled for an OGTT. A 75-g cola-flavored glucose solution (Dexpak, Miles Laboratories) was administered after an overnight fast, and capillary glucose was measured 2 h later, according to WHO recommendations. OGTTs were classified as diabetic (2-h glucose ≥11.1 mM), IGT (2-h glucose 7.8–11.0 mM), or nondiabetic (2-h glucose <7.8 mM). Subjects with diabetes and those who participated in the OGTT were weighed, measured, and administered a questionnaire concerning their education, occupation, family income, place of former residence, health conditions (present and past), obstetrical profile, current medication, alcohol and cigarette consumption, physical activity, and dietary habits.

The health professional teams working in each of the nine cities were trained by a central coordinating committee and were continuously supervised by a local coordinating physician during the field work. Quality control procedures regarding capillary blood glucose measurements were performed during the study. They consisted of a random comparison between strip results and simultaneous glucose-oxidase readings taken at standard laboratories; regression analysis yielded a correlation coefficient of 0.99 (n = 92; range 3.5–17.0 mM). In addition, the examiner's performance with reflectance meters was tested with standard glucose solutions, ranging from low (4.4–6.7 mM) to high (10.0–15.0 mM) glucose concentrations on a regular weekly basis throughout the field work in the nine cities. Each phlebotomist was required to have at least 24 consecutive readings, with the aforementioned standard solutions, falling within the 95% confidence limit of a skilled operator's set of readings.

The total sample of 21,847 individuals was divided into groups according to sex, age, skin color, level of education, presence of family history of diabetes, and presence of obesity to assess their influence on diabetes prevalence. Skin color was judged by the interviewer, and subjects were divided into white and nonwhite groups. Educational level was divided into less than junior

Table 1—*Participation rates and percentage distribution of eligible, screened, and OGTT samples*

		Screened sample			OGTT sample	
	Eligible	Total	Positive	Negative	Positive screenees	Negative screenees*
Participants	24,676	21,847	2,294	19,553	2,201	2,712
% (vs. selected)		88.5			96.0	93.6
Age (yr)						
30–39	38.7	38.9	22.1	40.8	21.8	38.5
40–49	26.6	26.4	23.9	26.7	23.7	26.9
50–59	20.6	20.5	30.0	19.5	30.3	20.8
60–69	14.0	14.2	24.0	13.0	24.2	13.8
Sex						
Male	42.8	41.0†	35.3	41.7	35.1	27.5‡
Female	57.2	59.0†	64.7	58.3	64.9	72.5‡
Skin color						
White	—		67.4	63.6	67.5	61.6§
Nonwhite	—		32.6	36.4	32.5	38.4§
Education						
Below junior high school	—		57.4	48.1	58.1	56.5‡
Junior high school or higher	—		42.6	51.9	41.9	43.5‡
Diabetes in family						
Yes	—		38.9	25.1	39.2	28.0‡
No	—		61.1	74.9	60.8	72.0‡

Previously diagnosed diabetic patients (832 confirmed and 190 unconfirmed at screening) and subjects without a history of diabetes with FCG ≥11.1 mM at screening (n = 94) are included as screen-positives in both samples. —, unavailable data.
*A 1 in 6.7 sample (n = 2,898) of negative screenees was selected for the OGTT.
†$P < 0.01$ (screened vs. eligibles).
‡$P < 0.01$. §$P = 0.04$ (OGTT vs. screened [negative screenees]).

high school and junior high school or higher. Obesity was defined as a BMI (weight/height^2) of ≥25 for women and ≥27 for men, according to the National Diabetes Data Group criteria (9). The sample of participants screened for FCG was compared with the eligible individuals living in the selected households for representativeness by age and sex. Screen-positive and -negative groups in the OGTT sample were compared with those in the screened sample for representativeness by age, sex, color, school level, and presence of family history of diabetes. In extrapolating prevalence rates from the OGTT sample to the screened sample, the cross-stratification technique (10) was used to correct for potential biases generated by underrepresentation of specific strata because of nonparticipation in the OGTT phase (as defined in the analyses of representativeness). Age adjustment of prevalence rates was performed by the direct method, the standard being the 1980 Brazilian population (7). χ^2 Tests were used for analysis of representativeness between samples and for comparisons of prevalence rates. Cochran partition tests (11) were used for defining contrasts among multiple comparisons when the χ^2 was significant. The level of significance was set at 0.05. Data storage and retrieval were performed with DBASE III PLUS software (Ashton-Tate). Data analysis was conducted through SPSS-X statistical software (Chicago, IL).

RESULTS— Analyses of representativeness and the participation rates at each stage of the survey are shown in Table 1. Among 16,104 households sampled in the nine cities, 3,090 (19.2%) had no eligible residents and 1,360 (8.5%) were lost to the survey because of refusal to participate (384 or 2.4%) or because the house was vacant at the time of the interview (976 or 6.1%). Of 24,676 eligible individuals, 21,847 (88.5%) participated in the screening phase and were the basis for estimates of diabetes and IGT prevalence. The mean number of individuals participating in each city was 2,427 (range 1,856–3,002). Nonwhites comprised 36% of participants, with 33.2% being blacks, 0.5% Asians, and 2.3% unclassified. There was no statistical difference in age distribution between the participants in the screening phase and the eligible individuals. However, the proportion of men participating in the screening phase (41.0%) was slightly lower than that found among the eligible individuals (42.8%) ($P < 0.01$). Among the screened sample, 832 persons had previously diagnosed diabetes and either were using insulin, had a history of glycemia ≥11.1 mM, or had FCG ≥ 11.1 mM at screening and thus were considered to have diabetes. An additional 94 persons without a history of diabetes had FCG ≥11.1 mM at screening and were considered to have undiagnosed diabetes. The diabetic individuals were included in the OGTT sample as screen-positives, but they were not administered the glucose tolerance test. In addition 190 individuals formerly known to have diabetes did not meet this criterion for diagnosis in the screening phase; 81 were without treatment, 68 were on dietary treatment only, and 41 were taking oral hypoglycemic drugs. These individuals were considered screen-positives and were administered the OGTT (those taking oral drugs were asked to stop medication for 2–3 days before the test); 54 had diabetes and were included in the previously diagnosed group, 51 had IGT, and 85 had normal glucose tolerance (previous abnormality of glucose tolerance [9]).

The OGTT sample comprised 2,201 screen-positive individuals (96.0% of the 2,294 selected were individuals with FCG 5.6–11.0 mM; those diagnosed as diabetic patients in the screening phase; and those previously diagnosed as diabetic patients, but not confirmed in the screening phase) and 2,712 screen-negative individuals (93.6% of the 2,898 selected were individuals with FCG <5.6 mM)—the net proportion of selection among the latter group having been 1 in 6.7. Among the screen-positives, 1,189 persons were considered to have diabetes and 297 persons were classified as having IGT, according to WHO criteria. Among the screen-negatives, 53 and 206 individuals were classified with diabetes and IGT, respectively. Extrapolation of these figures to the screened sample yielded 1,655 people with diabetes (1,242 among the screen-positives and 413 among the screen-negatives) and 1,704 with IGT (310 among the screen-positives and 1,394 among the screen-negatives). The positive screenees in the OGTT sample did not differ by age distribution, sex, color, educational level, or family history of diabetes from the positive screenees of the screened sample. The negative screenees participating in the OGTT phase had the same age distribution as the negative screenees of the screened sample, but there were statistically significant ($P < 0.05$) underrepresentation of men (27.5 vs. 41.7% in the screened sample) and whites (61.6 vs. 63.6% in the screened sample), and overrepresentation of less-educated individuals (56.5 vs. 48.1% in the screened sample) and of individuals with a family history of diabetes (28.0 vs. 25.1% in the screened sample). These differences and the lower proportion of men in the screened sample compared with the eligible individuals were considered when prevalence data were extrapolated from the OGTT sample to the screened sample, as described in METHODS.

The overall age-adjusted rates for diabetes and IGT were 7.4 and 7.7%, respectively (Table 2), with some regional differences. Both diabetes and IGT were more prevalent in the south and southeast (more industrialized) regions of the country. The highest rate of diabetes was found in Sao Paulo (9.7%, $P < 0.01$) and that of IGT in Porto Alegre (12.2%, $P < 0.01$). The lowest rates were seen in Brasilia (midwest region); 5.2 and 4.5% for diabetes and IGT, respectively ($P < 0.01$).

Age strongly influenced diabetes prevalence, with the rate in the 60–69-yr-old group (17.4%) being 6.4 times higher than that seen among people aged 30–39 yr (2.7%) ($P < 0.01$). An age trend also occurred for IGT prevalence, although not as marked as for diabetes: the rates increased from 5.9% in the 30–39-yr-old group to 11.2% in the 60–69-yr-old group ($P < 0.01$).

No difference was found for age-standardized diabetes prevalence between men (7.4%) and women (7.4%); however, women had a higher rate of IGT than men (8.4 vs. 6.7%, $P < 0.01$). Rates for diabetes did not differ in whites (7.5%) and nonwhites (7.1%); the same was observed for IGT (7.8 and 7.6% in whites and nonwhites, respectively). People with a lower (less than junior high school) level of education had higher crude rates of both diabetes (8.5%) and IGT (8.3%) than those with higher educational levels (6.7% for diabetes and 7.3% for IGT), but these differences were absent after adjusting for age: 7.1 vs. 7.8% for diabetes and 7.8 vs. 7.8% for IGT among the less and the better educated, respectively. The presence of a family history of diabetes and obesity was associated, respectively, with a 2.2- and 1.9-fold increase in age-adjusted diabetes prevalence and a 1.4- and 1.8-fold increase in age-adjusted IGT prevalence ($P < 0.01$).

Newly diagnosed diabetes (3.4%) accounted for 46% of the total age-adjusted diabetes prevalence. The percentage distribution of new cases ranged from 31% in Rio de Janeiro to 65% in Fortaleza. The prevalence of newly diagnosed diabetes was slightly higher than that of previously known diabetes in the 30–39-yr-old group (1.5 and 1.2%, respectively). As age increased, there was a shift in the distribution between new and diagnosed cases, with the rate for previously diagnosed diabetes being higher (9.9%) than that for new cases (7.5%) in the 60–69-yr-old group. Among women, there was a higher proportion of previously diagnosed diabetes: 4.5% compared with 2.9% for new cases (age-adjusted); the inverse was observed among men, whose age-standardized rates were 3.1 and 4.3% for previously known and unknown diabetes, respectively. The age-adjusted prevalence of newly diagnosed diabetes was the same in whites (3.5 or 47% of total) and nonwhites (3.3 or 46% of total). However, the percentage of diagnosed diabetes was slightly higher among people with lower levels of education (4.0 or 56% of total) than in those with higher educational

Table 2—*Prevalence of diabetes mellitus and IGT in the urban Brazilian population aged 30–69 yr*

	Diabetes mellitus (%)						IGT (%)	
	Crude			Age-adjusted*				
	Previous diabetes	New diabetes	Total	Previous diabetes	New diabetes	Total	Crude	Age-adjusted*
Overall	**4.1**	**3.5**	**7.6**	**4.0**	**3.4**	**7.4**	**7.8**	**7.7**
Region								
North								
Belem	3.5	3.8	7.3	3.3	3.9	7.2†[c]	9.5	9.5†[b]
Northeast								
Fortaleza	2.2	4.2	6.4	2.3	4.2	6.5†[d]	5.8	5.8†[d]
Joao Pessoa	4.4	4.0	8.4	3.8	4.1	7.9†[c]	7.2	7.2†[c]
Recife	3.8	2.9	6.7	3.5	2.9	6.4†[d]	5.4	5.4†[d]
Salvador	5.3	2.9	8.2	4.8	3.1	7.9†[c]	4.8	4.8†[d]
Midwest								
Brasilia	3.1	2.0	5.1	3.3	1.9	5.2†[e]	4.5	4.5†[d]
Southeast								
Rio de Janeiro	5.7	2.2	7.9	5.2	2.3	7.5†[c]	9.2	9.2†[b]
Sao Paulo	4.7	5.0	9.7	4.7	5.0	9.7†[a]	11.2	11.2†[a]
South								
Porto Alegre	4.6	4.2	8.8	4.8	4.1	8.9†[b]	12.2	12.2†[a]
Age (yr)								
30–39	1.2	1.5	2.7†[d]				5.9†[d]	—
40–49	2.8	2.7	5.5†[c]				7.2†[c]	—
50–59	7.1	5.6	12.7†[b]				9.8†[b]	—
60–69	9.9	7.5	17.4†[a]				11.2†[a]	—
Sex								
Male	3.1	4.4	7.5	3.1	4.3	7.4	6.7	6.7†[b]
Female	4.7	2.9	7.6	4.5	2.9	7.4	8.5	8.4†[a]
Skin color								
White	4.2	3.6	7.8	4.0	3.5	7.5	7.9	7.8
Nonwhite	3.8	3.4	7.2	3.8	3.3	7.1	7.6	7.6
Education								
Below junior high school	4.7	3.8	8.5	4.0	3.1	7.1	8.3	7.8
Junior high school or higher	3.4	3.3	6.7	3.8	4.0	7.8	7.3	7.8
Diabetes in family								
Yes	7.3	5.2	12.5	7.3	5.2	12.5†[a]	9.9	10.0†[a]
No	2.9	2.9	5.8	2.8	2.8	5.6†[b]	7.0	6.9†[b]
Obesity‡								
Yes	6.0	5.5	11.5	5.3	5.0	10.3†[a]	11.1	10.8†[a]
No	2.9	2.4	5.3	3.0	2.5	5.5†[b]	5.8	5.9†[b]

*Standard = Brazilian population according to the 1980 census.
†P < 0.01 ($a > b > c > d > e$).
‡Males, BMI ≥ 27 kg/m^2; females, BMI ≥ 25 kg/m^2.

levels (3.8 or 49% of total). The presence of diabetes in the family was associated with a higher prevalence of previously diagnosed diabetes: the age-adjusted rates were 7.3% (58% of total prevalence) in the group with and 2.8% (50% of total) in those without a family history of diabetes. Among the obese, newly diagnosed cases accounted for 48% of the total age-standardized diabetes prevalence, whereas in the nonobese this percentage was 45%.

Figure 2 depicts the percentage distribution of current therapy among previously diagnosed diabetic patients in the nine cities. Most of the patients (40.7%) were on oral hypoglycemic agents, whereas only 7.9% were on in-

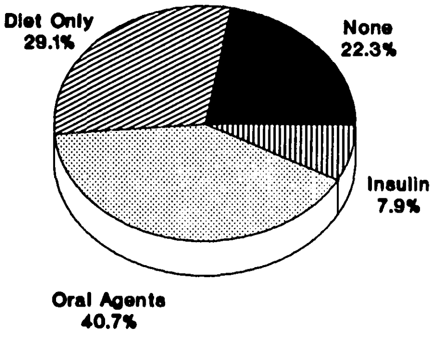

Figure 2—*Percentage distribution of type of treatment among 894 previously diagnosed diabetic patients for whom this information was available.*

sulin therapy. A significant proportion of patients (22.3%) was not being treated by the time of the survey, and 29.1% were on dietary treatment only.

Data on self-reported diabetes were obtained for all members of the enumerated households, although glucose measurements were performed only on the eligibles. Figure 3 shows the self-reported prevalence of diabetes for all

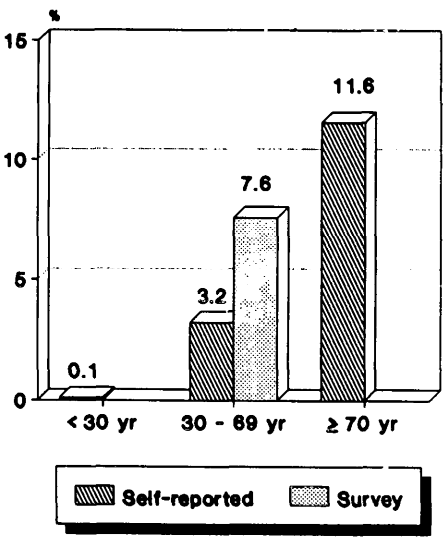

Figure 3—*Self-reported prevalence of diabetes in the age ranges <30, 30–69, and ≥70 yr. The rate from the survey for the 30–69-yr-old group also is shown.*

ages obtained by interview in the enumerated households. The rates were 0.1% in the population aged <30 yr, 3.2% (or 42% of the true prevalence) in the 30- to 69-yr-old age group, and 11.6% among those >70 yr.

CONCLUSIONS— In this study, it was found that diabetes mellitus is present in 7.6% of the urban Brazilian population aged 30–69 yr and that an additional 7.8% have IGT. Age-adjusted rates of diabetes and IGT varied across the country, ranging from 5.2 to 9.7% and from 4.5 to 12.2%, respectively. The highest rates were found in the south and southeast, the more economically developed regions of Brazil. The same rates of diabetes were observed among men and women. The rates were similar in whites and nonwhites. Age, obesity, and the presence of a family history of diabetes were the most important factors associated with an increase in diabetes prevalence. In addition, it was found that 46% of the total diabetes prevalence is made up of newly diagnosed cases.

Prevalence studies can provide information about the magnitude of medical resources that must be assigned to cope with a specific disease and to plan programs for its control and prevention. They can also increase our knowledge about a disease and be used to rank it properly among other competing priorities. Moreover, risk factors for a disease can be revealed by prevalence studies, provided they exist before the disease onset and do not substantially affect its mortality. Diseases of such a multifactorial origin as diabetes seem to develop as a consequence of the interaction between genetic and environmental risk factors.

The data obtained in this study indicate that the occurrence of diabetes and IGT in Brazil is similar to that found in countries such as the U.S., Italy, Israel, Argentina, and others (12). Diabetes prevalence seems to be increasing in the last decades in these countries. In the U.S., for example, self-reported rates of diabetes rose from 0.4 to 2.5% between 1935 and 1981, the ratio of diagnosed/undiagnosed cases having been 1:1 in the last surveys (10). The reasons for this increase may be the change in diagnostic criteria or the increase in population longevity, but the rates of diabetes incidence and mortality also have changed (13). The changes in diabetes prevalence over time in Brazil are unknown, because this is the first national prevalence study. Factors associated with an increase in diabetes prevalence, such as longer life expectancy and growing urbanization, are accumulating in Brazil (6), but diabetes mortality also seems to be increasing (2).

The observed regional differences in diabetes and IGT prevalence in Brazil may be related to the difference in longevity and urbanization of the populations, the south and southeast regions being more industrialized and having an older population than the others (14). These differences also held, however, for age-adjusted rates, which ranks population longevity as a less important factor. Although we found no statistically significant differences in diabetes prevalence by race, differences in ethnicity do exist across the country. In the north and northeast, there are more blacks and Indians than in the south and southeast, where whites predominate. However, it is difficult to quantify these differences because of the high degree of interracial marriage that has characterized the Brazilian population since colonial times (15). Also, internal migration has been massive and rapid in the last decades, making more difficult the racial characterization of populations living in our large cities. The search for medical care for diabetes may be another reason why internal migration contributes to the higher prevalence of diabetes in the south and southeast, which have many more medical facilities available. Another factor could be a difference in diabetes mortality, which seems to be higher in the northeast than in the southeast (2,16,17).

In this study, diabetes prevalence

rates were found to be >6 times higher in the 7th decade of life than in the 4th. Either the presence of obesity or diabetes in the family were associated with rates nearly twofold those seen in their absence. These observations are in agreement with the concept that age, heredity, and obesity are the universal risk factors for type II diabetes (18).

Based on the survey data, almost half (46%) of diabetic subjects aged 30–69 yr in Brazil are undiagnosed, the percentage of newly diagnosed diabetes having ranged from 31 to 65% in the nine cities. These figures can be compared with those of Harris et al. (10), who found that undiagnosed diabetes constitutes 48.5% of all cases in the U.S. Moreover, if the self-reported prevalence of diabetes in people aged >70 yr is also ~50% the total, we can speculate that the rate of diabetes may be as high as 25% in this oldest age range. Conversely, the self-reported diabetes rate we found in people <30 yr (0.1%) must be close to the total rate, because in this age range most patients have type I diabetes, (19), in which case the disease is hardly ever unrecognized.

Twenty-two percent of the diagnosed cases were not being treated at the time of the survey. This finding calls for efforts to improve health education and stresses the need for a long-term commitment to populational screening for diabetes. On the other hand, the percentage of diabetic subjects being treated with insulin (7.9%) can be considered low, compared with published figures (20,21). This may stem from undue prejudice against insulin therapy by patients and/or practitioners, but it also may be attributable to a low incidence of type I diabetes. A high mortality rate among type I patients might also explain this. The need for studies on diabetes mortality in the Brazilian population, particularly in the <30-yr age-group, cannot be overemphasized.

Brazil has an estimated population for 1990 of 150 million, with 66.5% <30 yr of age, 31% aged 30–69 yr, and 2.5% >70 yr (7). If we extrapolate our results to the general population, according to these figures, the total number of diabetic subjects in the country can be estimated to be 4.5 million. Of these, 2 million individuals are unaware of their disease, and one-half million patients with known diabetes are not being treated with accepted diabetes therapies. We can conclude that diabetes mellitus probably is the most important endocrine–metabolic disease in Brazil and that its impact on public health is comparable with that in more developed nations, where it is considered a major health problem.

Acknowledgments— This study was supported by the Brazilian Ministry of Health, the National Council for Scientific and Technological Development, the Pan-American Health Organization, (CNPq) and the Sao Paulo Foundation for Research Support (FAPESP).

We thank Dr. Michael Stern for his assistance in planning the work and analyzing the data; Dr. Marco Antonio Vivolo for his help with the data management system; Drs. Sergio Pereira de Almeida Toledo and Maureen Harris for their expert critical revision of the manuscript; and Brian Weymouth for the language revision.

This work was presented in abstract form at the 14th annual meeting of the International Diabetes Federation, Washington, DC, 1991.

APPENDIX—THE BRAZILIAN COOPERATIVE GROUP ON THE STUDY OF DIABETES PREVALENCE—

Steering committee

Laercio J. Franco, Adolpho Milech, Domingos Malerbi, Maria Ines Schmidt, Luciano Almeida, Augusto Pimazoni Netto, Reginaldo H. Albuquerque, Corina D. C. Braga.

Participating centers

Laercio Franco, Katsumi Osiro (Sao Paulo); Ines Lessa, Judith D. C. Pousada (Salvador); Maria Ines Schmidt, Maria Ines Azambuja (Porto Alegre); Adolpho Milech, Jose Egidio P. Oliveira (Rio de Janeiro); Laurenice P. Lima, Jose B. Peniche (Brasilia); Luciano Almeida, Francisco Bandeira (Recife); Waldenice Ohana, Bruno Urbinati, Nizomar Carneiro (Belem); Adriana C. Forti, Maria Ferreira Guimaraes (Fortaleza); Joao Modesto Filho, Ilka M. L. Araujo (Joao Pessoa).

References

1. Briscoe J: *Brazil: The New Challenge of Adult Health. A World Bank Country Study.* Washington, DC, The International Bank for Reconstruction and Development/The World Bank, 1990
2. Laurenti R, Fonseca LAM, Costa ML Jr: Mortalidade por diabetes mellitus no municipio de Sao Paulo (Brasil). *Rev Saude Publ Sao Paulo* 16:77–91, 1982
3. Wilson D: *Contribuição para o Conhecimento da Epidemiologia do Diabetes Mellitus. Aspectos da sua Prevalencia na Cidade de Jarinu, Estado de Sao Paulo.* Sao Paulo, Univ. Sao Paulo Public Health School, 1964
4. Wilson D: Estudos sobre as provas de tolerancia a glicose potencializadas em reclusos da penitenciaria do Estado de Sao Paulo. I. Prevalencia do diabetes mellitus. *Arq Fac Hig Saude Publ Sao Paulo* 20:129–37, 1966
5. Achutti A, Medeiros AMB: Hipertensão arterial no Rio Grande do Sul. *Bol Saude* 12:6–54, 1985
6. Ministerio da Saude do Brasil: *Controle das Doenças não Transmissiveis no Brasil.* Brasilia, Centro de Documentação do Ministerio da Saude, 1986
7. Fundação Instituto Brasileiro de Geografia e Estatistica: *Anuario Estatistico do Brasil.* Rio de Janeiro, Brazil, 1985
8. Lapin LL: Statistics—meaning and method. New York, Harcourt Brace Jovanovich, 1975, p. 74–87
9. National Diabetes Data Group: Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes* 28:1039–57, 1979
10. Harris MI, Hadden WC, Knowler WC,

Bennett PH: Prevalence of diabetes and impaired glucose tolerance and plasma glucose levels in U.S. population aged 20–74 years. *Diabetes* 36:523–34, 1987
11. Cochran WG: Some methods for strengthening the common χ^2 test. *Biometrics* 10:417–51, 1954
12. King H, Zimmet P: Trends in the prevalence and incidence of diabetes: non-insulin-dependent diabetes mellitus. *World Health Stat Q* 41:190–96, 1988
13. Harris MI: Prevalence of non-insulin-dependent diabetes and impaired glucose tolerance. In *Diabetes in America*. Bethesda, MD, U.S. Department of Health and Human Services, National Institutes of Health, 1985, p. VI/1–31
14. Becker RA, Lima JTF, Costa ML Jr, Eds.: *Investigação Sobre Perfis de Saude: Brasil, 1984*. Brasilia, Centro de Documentação do Ministerio da Saude, 1989
15. Prado C Jr: *Formação do Brasil Contemporaneo*. Sao Paulo, Editora Brasiliense, 1987
16. Lessa I, Oliveira ZC, Boa Sorte A, Cabral MS: Diabetes mellitus como causa basica e como causa associada de morte em Salvador, Brasil. *Arq Bras Med* 60:467–72, 1986
17. Melo MS: *Mortalidade por Diabetes Mellitus no Municipio do Recife, no Periodo 1961–1987*. Recife, Centro de Ciencias da Saude da Univ. Federal de Pernambuco, 1990
18. Everhart J, Knowler WC, Bennett PH: Incidence and risk factors for non-insulin-dependent diabetes. In *Diabetes in America*. Bethesda, MD, U.S. Department of Health and Human Services, National Institutes of Health, 1985, p. IV/1–35
19. Krolewsky AS, Martin B, Warram JH: Epidemiological features of the natural history of diabetes as clues for etiologic studies. In *World Book of Diabetes in Practice*. Krall LP, Ed. Amsterdam, Elsevier, 1988, p. 59–64
20. Martin DB, Quint AR: Therapy for diabetes. In *Diabetes in America*. Bethesda, MD, U.S. Department of Health and Human Services, National Institutes of Health, 1985, p. XXIV/1–30
21. Foss MC, Paccola GM, Souza NV, Iazigi N: Estudo analitico de uma amostra populacional de diabeticos tipo II da região de Ribeirão Preto (SP). *Rev Ass Med Bras* 35:179–83, 1989