Published in final edited form as:

Endocr Pract. 2016 October ; 22(10): 1151–1160. doi:10.4158/EP151144.OR.

IDENTIFYING PROBABLE DIABETES MELLITUS AMONG HISPANICS/LATINOS FROM FOUR U.S. CITIES: FINDINGS FROM THE HISPANIC COMMUNITY HEALTH STUDY/ STUDY OF LATINOS

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Disclosures: The authors have nothing to disclose.

Disclaimer: The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institutes of Health; or the U.S. Department of Health and Human Services.

Abstract

Objectives: The aim of this study was to compare the ability of American Diabetes Association (ADA) diagnostic criteria to identify U.S. Hispanics/Latinos from diverse heritage groups with probable diabetes mellitus, and assess cardiovascular risk factor correlates of those criteria.

Methods: Cross-sectional analysis of data from 15,507 adults from six Hispanic/Latino heritage groups, enrolled in the Hispanic Community Health Study/Study of Latinos. The prevalence of probable diabetes mellitus was estimated using individual or combinations of ADA-defined cut points. The sensitivity and specificity of these criteria at identifying diabetes mellitus from ADA-defined pre-diabetes and normoglycemia were evaluated. Prevalence ratios of hypertension, abnormal lipids, and elevated urinary albumin-creatinine ratio for unrecognized diabetes mellitus – versus pre-diabetes and normoglycemia – were calculated.

Results: Among Hispanics/Latinos (mean age 43 years) with diabetes mellitus 39.4% met laboratory test criteria for probable diabetes; and the prevalence varied by heritage group. Using the OGTT as the gold standard, the sensitivity of fasting plasma glucose (FPG) and hemoglobin A_{1c}-alone or in combination- was low (18%, 23% and 33%, respectively) at identifying probable diabetes mellitus. Individuals who met any criterion for probable diabetes mellitus had significantly higher ($P < 0.05$) prevalence of most cardiovascular risk factors than those with normoglycemia or prediabetes, and this association was not modified by Hispanic/Latino heritage group.

Conclusions: FPG and HbA_{1c} are not sensitive (but highly specific) at detecting probable diabetes mellitus among Hispanics/Latinos, independent of heritage group. Assessing cardiovascular risk factors at diagnosis might prompt multi-target interventions, and reduce health complications in this young population.

Keywords

probable diabetes mellitus; fasting plasma glucose; oral glucose tolerance test; hemoglobin A_{1c}; Hispanics; Latinos; cardiovascular risk factors

Introduction

Diabetes mellitus is one of the most common chronic diseases in our society and throughout the world. In 2012, it was estimated that 29 million people in the U.S. had diabetes mellitus, and 1.7 million new diagnoses were made that year [1]. Early and accurate detection of the disease is a fundamental step towards the reduction of diabetes-related complications and their associated health burden.

In 2010, the American Diabetes Association (ADA) recommended specific cut points for fasting plasma glucose (FPG), post oral glucose tolerance test (OGTT), and hemoglobin A_{1c} (HbA_{1c}) for the diagnosis of diabetes mellitus [2]. Prior to and after the publication of those recommendations, the sensitivity, variability, and reproducibility of these tests according to age, sex [2–11], and racial/ethnic group [12–14] have been questioned. Due to the high risk for developing diabetes mellitus documented in the general Hispanic/Latino population [15–17], and their diverse ethnic/racial, socioeconomic, and cultural backgrounds, it would be

clinically useful to examine whether current ADA recommended criteria for the diagnosis of diabetes mellitus are comparable for Hispanics/Latinos of different heritage groups.

Using data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) baseline examination, we evaluated in this population-based cohort the prevalence of probable diabetes mellitus according to the individual ADA diagnostic criteria [2] and their combinations, and determined whether the prevalence differed by age, sex, and Hispanic/Latino heritage group categories. We also examined the sensitivity and specificity of these tests at identifying individuals with probable diabetes mellitus from individuals with pre-diabetes and from those with normal glucose tolerance, and compared the prevalence of selected cardiovascular risk factors among individuals with probable diabetes mellitus compared to individuals with pre-diabetes and normal glucose tolerance.

Methods

The HCHS/SOL study and sampling designs have been published elsewhere [18,19]. Briefly, the HCHS/SOL is a longitudinal, population-based study whose objectives include describing the prevalence of selected chronic diseases; identifying their risk and/or protective factors; and quantifying mortality and morbidity. From March 2008 to June 2011, 16,415 persons, aged 18–74 years at the time of screening, who self-identified as Hispanics/Latinos were examined. Participants were recruited following a multi-stage probability sampling of the communities in San Diego, California; Chicago, Illinois; Miami, Florida; and the Bronx, New York. The study was approved by each of the Field Center's and the Coordinating Center's Institutional Review Board. All enrolled individuals provided signed informed consent. Approximately 93% of participants completed all study procedures.

Interviews (self-identified Hispanic/Latino heritage group, family history of diabetes, place of birth, and years living in the U.S.), phlebotomy, processing of biospecimens, and anthropometric measurements [including body mass index (BMI)] were performed by trained and certified staff following a standard protocol [www.csc.unc.edu/hchs]. Place of birth was defined as born in U.S. mainland (born in any of the 50 States), and born outside of the U.S. mainland (born outside of the 50 states). Participants were asked to consume only water and necessary medications after 10 p.m. the night before the baseline visit, and refrain from smoking or physical activity before undergoing the fasting examination procedures. The examination of pregnant women was postponed until three months postpartum. Individuals with other chronic diseases or health conditions were not excluded from the study. All participants had FPG and HbA_{1c} measured. After the initial venipuncture, those without self-reported diabetes mellitus and/or who were not taking antihyperglycemic medications and/or a FPG ≥ 8.4 mmol/L underwent a standard 75 g two-hour OGTT.

Plasma glucose, serum high-density lipoprotein-cholesterol (HDL-C), and serum triglycerides (TG) were measured using a Roche Modular P Chemistry Analyzer (Roche Diagnostics Corporation); urine albumin was measured using an immunoturbidometric method on the ProSpec nephelometric analyzer (Dade Behring GMBH, Marburg, Germany D-35041); and HbA_{1c} concentration was measured in EDTA whole blood using a Tosoh G7

Automated HPLC Analyzer. Low-density lipoprotein cholesterol (LDL-C) was not measured directly, but estimated using the Friedewald's formula when TG < 4.5 mmol/L. The distinction between Type 1 and Type 2 diabetes mellitus was not specifically assessed in the medical history interview or through laboratory tests. C-peptide, islet cell antibodies, insulin (receptor) autoantibodies, or glutamic acid decarboxylase (GAD) antibodies were not measured.

Definition of probable diabetes mellitus and pre-diabetes states

Using the ADA criteria [2], participants without self-reported diabetes mellitus and who were not taking antihyperglycemic medications were classified as having probable diabetes mellitus [FPG ≥ 7.1 mmol/L and/or 2hPG ≥ 11.2 mmol/L and/or HbA_{1c} ≥ 48 mmol/mol (6.5%)]; or pre-diabetes [impaired fasting glucose (IFG), FPG = 5.6–7.0 mmol/L and/or impaired glucose tolerance (IGT), 2hPG = 7.8–11.1 mmol/L and/or impaired HbA_{1c}, HbA_{1c} = 39–46 mmol/mol (5.7–6.4%)]. The three tests were normal in individuals with normal glucose tolerance (NGT) [FPG < 5.6 mmol/L and 2hPG < 7.8 mmol/L and HbA_{1c} < 39 mmol/mol (5.7%)]. Individuals with at least one diabetes mellitus criterion were classified within the probable diabetes mellitus category, and were not accounted in the other diabetes status categories. Data from individuals with probable diabetes mellitus, pre-diabetes, and NGT were included in the analyses that follow.

The total number of enrolled individuals was 16,415 [20]. Individuals with missing diabetes mellitus screening laboratory data (n = 832) or whose age was outside of the selected range (n = 9) or who were taking antihyperglycemic medications and did not report having diabetes mellitus (n = 67) were not included in the analysis. A total of 15,507 individuals had complete sets of relevant data for this analysis. Among these, individuals with self-reported diabetes mellitus (n = 2,148) were also excluded. Among the remaining 13,359 individuals, 6,329 (weighted prevalence = 45%) were classified as having NGT; 5,836 (36.3%) as having pre-diabetes, and 1,194 (6.7%) as having probable diabetes mellitus.

Definition of Cardiovascular Risk Factors

Selected cardiovascular (CV) risk factors were defined based on current national guidelines. Hypertension was defined as a systolic blood pressure ≥ 140 mm Hg, a diastolic blood pressure ≥ 90 mm Hg, or taking antihypertensive medications. Low HDL-C was defined as < 1.2 mmol/L in men and < 1.4 mmol/L in women; high LDL-C was defined as ≥ 3.4 mmol/L; high TG levels were defined as ≥ 1.7 mmol/L; high urine albumin/creatinine ratio (UACR) was defined as > 30 mg/g; and obesity was defined as BMI ≥ 30 kg/m².

Statistical Analysis

All reported values were weighted by sampling weights using survey-specific procedures to account for the multi-stage sampling design, stratification, and clustering [21,22]. The sampling weights were calculated as the product of a “base weight” (reciprocal of the probability of selection) and three adjustments: (1) non-response adjustments made relative to the sampling frame, (2) trimming to handle extreme values (to avoid a few weights with extreme values being overly influential in the analyses), and (3) calibration of weights to the 2010 U.S. Census according to age, sex, and Hispanic/Latino heritage group. The age, sex,

and Hispanic/Latino heritage groups distributions based on the sampling weighted estimates were very similar to the Census 2010 population within the target recruitment areas, with size of the differences below 0.45% in the majority of cases.

Prevalence of total probable diabetes mellitus and its individual criteria was age-standardized to the year 2010 U.S. Census population and reported as percentages with 95% confidence intervals (95% CI). Prevalence estimates were compared according to sex, age and Hispanic/Latino heritage groups using multilog modeling based Wald Chi square test. P-values were reported for the sex and age group comparisons and the overall comparison across Hispanic/Latino heritage groups. A Venn diagram was constructed to illustrate the concordance and discordance among FPG-, HbA_{1c}-, and 2hPG-based probable diabetes mellitus criteria.

Marginal logistic regression models were used to estimate the sensitivity and specificity of the diagnostic criteria for probable diabetes mellitus. The OGTT has long been recognized as the gold standard test for the detection of early abnormalities of glucose homeostasis. Because FPG or HbA_{1c} are very often used in clinical settings to detect diabetes mellitus (rather than the OGTT), we compared the sensitivity and specificity of FPG alone, HbA_{1c} alone, and the combination of these two using the OGTT (2hPG) as the gold standard in the target population and across age, sex, and BMI subpopulations.

We next examined the association between probable diabetes mellitus and CV risk factors. Adjusted prevalence ratios (PRs) of the selected CV risk factors were estimated with 95% CI [Model 1] using Poisson regression. The Taylor series linearization approach was used to compute robust estimates of standard errors for the regression coefficients and confidence intervals for the PRs [23,24]. The PR indicates the magnitude of the prevalence of a CV risk factor among individuals with probable diabetes mellitus to that among individuals who met any of the pre-diabetes criteria and to that among individuals with NGT. Individual CV risk factors were modeled for: (a) the comparison between individuals who met any of the probable diabetes mellitus criteria and individuals with NGT; (b) the comparison between individuals who met any of the probable diabetes mellitus criteria and individuals who met any pre-diabetes criteria; and (c) the comparison between individuals who met any of the probable diabetes mellitus criteria and individuals who met all three pre-diabetes criteria. These three comparisons were adjusted for age, sex, and Hispanic/Latino heritage group. Because the sample sizes for individuals who met individual ADA criteria were small, PRs for CV risk factors were not computed. To determine whether Hispanic/Latino heritage group modified the association between glycemic status and individual CV risk factors, an interaction term was included in the full model (adjustments for age, sex, and Hispanic/Latino heritage group) and assessed using the likelihood ratio test.

Statistical tests were two-sided at a significance level of 0.05. Adjustments for multiple comparisons were not made. All analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC), SUDAAN release 10.0.0 (Research Triangle Institute, Raleigh, NC), and Stata version 13 (StataCorp, LP, College Station, TX).

Results

The prevalence of individuals who met at least one criterion of probable diabetes mellitus in the target population was very similar (6.7% vs. 6.2%) to that previously reported [25] [Table 1]. This means that among all individuals with diabetes mellitus 39.4% had probable diabetes.

Table 1 illustrates the total prevalence of probable diabetes mellitus (individuals who met at least one of the diagnostic criteria), as well as the prevalence of its major glyceimic subcategories. The prevalence of probable diabetes mellitus, as well as the prevalence of the individual glyceimic criteria, was similar between men and women, except total 2hPG 11.2 mmol/L, which was higher among women ($p = 0.015$). The total prevalence of probable diabetes mellitus, total FPG 7.1 mmol/L (FPG 7.1 mmol/L + any 2hPG + any HbA_{1c}), total HbA_{1c} 48 mmol/mol (HbA_{1c} 48 mmol/mol + any FPG + any 2hPG), and the combination of FPG 7.1 mmol/L + HbA_{1c} 48 mmol/mol (6.5%) varied significantly ($p < 0.05$) among Hispanic/Latino heritage groups. The prevalence of probable diabetes mellitus or its glyceimic subcategories consistently increased with increasing BMI, and was higher among individuals with family history of diabetes mellitus. The overall prevalence of probable diabetes mellitus tended to be lower among individuals born in the U.S. mainland compared to those born outside of the U.S. mainland. After stratifying by age group, this difference was more prominent among individuals aged 60–74 years, independent of number years in the U.S. [data not shown].

Figure 1 illustrates the concordance and discordance of the most prevalent criteria for probable diabetes mellitus and their combinations. Among the 1,194 individuals with probable diabetes mellitus, 500 met two or more ADA diagnostic criteria. More than half of individuals with 2hPG 11.2 mmol/L had it isolated. Most of those with FPG 7.1 mmol/L or HbA_{1c} 48 mmol/mol (6.5%) had them in combination with other glyceimic criteria.

Some individuals were classified as having probable diabetes mellitus based on one or more ADA criteria, and might have also met one or two criteria for pre-diabetes or NGT. Thus, we evaluated the sensitivity and specificity of FPG and HbA_{1c} alone and in combination – compared to 2hPG, the gold standard – to identify individuals with probable diabetes mellitus from individuals with NGT or pre-diabetes [Table 2]. Compared to 2hPG, the sensitivities of FPG and HbA_{1c}, either alone or in combination with FPG, were low (18.7%, 28.3%, and 33.0%, respectively), although the specificities remained high (99.7%, 99.3%, and 99.1%, respectively). Both the sensitivity and specificity of the selected comparisons increased with BMI, but not with age.

We determined the prevalence of the selected CV risk factors among individuals with NGT, pre-diabetes (any criteria), pre-diabetes (all criteria), and probable diabetes mellitus, and compared the prevalence of CV risk factors between individuals with probable diabetes mellitus and the other diabetes status categories using the PRs [Table 3]. With the exception of hypertension and obesity, the prevalence of CV risk factors was generally higher among individuals with probable diabetes and lowest among those with NGT. After adjusting for age, sex, BMI, and Hispanic/Latino heritage group, individuals with probable diabetes

mellitus had significantly greater prevalence of hypertension, low HDL-C, high TG, high UACR, and obesity than individuals with NGT. Individuals with probable diabetes mellitus had significantly greater prevalence of low HDL-C, high TG, high UACR, and obesity than individuals who met any pre-diabetes criteria, and only significantly greater prevalence of UACR than those who met all three criteria for pre-diabetes. The associations of diabetes status category with individual CV risk factors did not vary across Hispanic/Latino heritage group ($P > 0.10$) [data not shown].

Discussion

The findings of this HCHS/SOL-based analysis suggest that 6.7% of Hispanics/Latinos – almost 40% of those with diabetes mellitus – met laboratory diagnostic criteria and were not aware of having the disease. This prevalence varied by Hispanic/Latino heritage group, being the highest among Mexican, Central American, and South American groups. Two-hour post OGTT glucose ≥ 11.2 mmol/L was the most prevalent ADA diagnostic criterion among all heritage groups, and FPG and HbA_{1c} demonstrated low sensitivity at detecting probable diabetes mellitus in this population. Individuals with probable diabetes mellitus had greater prevalence of most CV risk factors evaluated than individuals with NGT or any pre-diabetes criterion. To our knowledge, our study is the first to compare the prevalence of probable diabetes mellitus based on the three diagnostic criteria in a contemporary cohort of U.S. Hispanics/Latinos from diverse heritage groups.

The higher prevalence of 2hPG ≥ 11.2 mmol/L had been previously reported by Cowie and colleagues in an analysis based on the NHANES 1988–2006 cycles [16]. The observed higher prevalence of elevated 2hPG among women and with increasing age in this study has been reported in the U.S. general population [26] and in European cohorts [27]. The inability of FPG or HbA_{1c} to identify individuals with probable diabetes mellitus is consistent with findings from the Strong Heart Study [28], but inconsistent with a study performed in Sweden [29]. In addition, the lower sensitivity of HbA_{1c} alone compared to 2hPG observed in the HCHS/SOL is consistent with other reports [5,30]. The observed differences in sensitivity within the HCHS/SOL may be explained in part by nutrition, alcohol intake, medications, comorbidities, hematologic factors affecting HbA_{1c} levels, and glycometabolic differences related to the duration of overweight/obesity and distribution of body fat [31], among other factors.

There are some HCHS/SOL findings that deserve attention. Hispanics/Latinos with probable diabetes mellitus are young (mean age of 43 years). As discussed in our analysis on the prevalence of pre-diabetes [32], these findings suggest that screening for diabetes mellitus needs to start before age 45 years, the cut point recommended by the ADA [2], and that awareness and interventions to prevent diabetes mellitus in Hispanics/Latinos would need to start much earlier in life. These findings also suggest that there are young Hispanics/Latinos with probable diabetes mellitus who could benefit from early interventions to prevent diabetes-related complications. The lack of a direct relationship between the prevalence of probable diabetes mellitus and years living in the U.S. suggests that some foreign born young Hispanics/Latinos had the disease or were at high risk of developing diabetes mellitus before moving to the U.S. This observation is congruent with reports on the increasing

prevalence of cardiometabolic risk factors and chronic diseases –including diabetes mellitus – throughout Latin America [33–35].

The high prevalence of probable diabetes mellitus among the diverse heritage groups represented in the HCHS/SOL is a long-term public health issue. This was first reported by the 1982–1984 Hispanic Health and Nutrition Examination Survey [36], and documented in Mexican Americans by the National Health and Nutrition Examination Survey (NHANES) [16,17] thereafter. More recently, Selvin et al. [37] observed that the prevalence of undiagnosed diabetes mellitus was higher in non-Hispanic Blacks and Mexican Americans compared to non-Hispanic Whites, and this disparity in prevalence has increased over the past 20 years.

The observed differences in total prevalence of probable diabetes mellitus and its subcategories among heritage groups in the HCHS/SOL may be explained by biological factors previously mentioned and others. The age and sex distribution within each heritage group might have influenced the predominance of a specific glycemic subcategory. Inadequate health insurance coverage among younger adults [data not shown], or insufficient local resources for screening and continuity of care, among other factors may also explain the differences in prevalence among groups. On the other hand, 83% of HCHS/SOL individuals aged 65 years and older had health insurance [data not shown], yet the prevalence of probable diabetes mellitus in this age group –although the sample size was small- was remarkable. The reasons for this persistent unawareness among Hispanics/Latinos needs to be fully understood, and effective interventions designed accordingly.

FPG, OGTT, and HbA_{1c} assess different mechanisms leading to changes in glucose homeostasis, which may occur at different times in the disease process and may not be captured by a one-time testing or through a cross-sectional analysis. Impaired biphasic insulin secretion after food intake leads to postprandial hyperglycemia, which is considered the earliest abnormality in glucose homeostasis and is assessed via the OGTT. Increased hepatic glucose output leads to fasting hyperglycemia and could emerge independent from or coexist with postprandial hyperglycemia. Elevation of HbA_{1c} to the diabetes mellitus range may also occur slowly during the early stages of the disease. The HCHS/SOL data suggest that the use of FPG or HbA_{1c} would fail to detect the disease in over two thirds of individuals with isolated 2hPG ≥ 11.2 mmol/L and most of those individuals would be women. Despite the known variability and low repeatability of the OGTT [9,10], the HCHS/SOL findings are consistent with the previously documented high sensitivity and specificity of the OGTT [3,4] at detecting diabetes mellitus compared to FPG and HbA_{1c}. These findings also highlight the opportunity for further research on alternative tests to the OGTT [38,39], which could assess postprandial and/or mean glucose levels in a manner more practical for busy clinical settings.

The greater PRs for CV risk factors among individuals with probable diabetes mellitus suggest the need for multiple interventions at diagnosis across Hispanic/Latino groups. The similarity of the PRs between individuals with probable diabetes mellitus and those who met all three pre-diabetes criteria suggests that the former were at an early disease stage. The significant PR for UACR is consistent with the previously described association between

UACR and diabetes mellitus in this population [40]. Since a second examination of study participants is in progress, we will be able to truly determine risk of cardiovascular disease related to glycemic criteria in association with CV risk factors in the near future.

The findings described in this analysis need to be interpreted within the context of other limitations. The study did not assess the presence of Type 1 diabetes mellitus. In addition, the cohort is not a nationally representative sample. However, the target population of the HCHS/SOL resides in four of the 11 urban areas with the largest number of Hispanics/Latinos, and four of the five largest U.S. Hispanic/Latino heritage groups are represented in the study. Like we observed in the separate analysis on pre-diabetes [34], the potentially variable reliability and repeatability of the three tests might have led to under- or overestimation of glycemic abnormalities. Like in the NHANES [15–17,26], the prevalence of diabetes mellitus in our cohort was assessed based on a medical interview and one set of laboratory tests. Five hundred (41%, unweighed percentage) of the individuals with probable diabetes mellitus met two or more ADA diagnostic criteria. Those who met one of the three criteria would have needed confirmatory tests, as recommended by the ADA [2], but these were not performed in the study.

In summary, probable diabetes mellitus is highly prevalent among U.S. Hispanics/Latinos, independent of heritage group. Our study findings illustrate the importance of evaluating more than one of the mechanisms of glucose metabolism to identify Hispanics/Latinos with probable diabetes mellitus. The prevention and early detection of diabetes mellitus as well as early interventions on associated cardiovascular risk factors in this young and rapidly growing population should undeniably continue to be a top U.S. public health priority.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Thanks: The authors thank the more than 250 staff members across Field Centers, whose dedication and ceaseless energy made the recruitment and baseline examination a success; and the over 16,000 participants who believed in making a difference, *¡Gracias por su participación y apoyo continuo! Gracias a ustedes, el Estudio SOL continúa.*

Previous presentation: Analyses based on the first year of data collection (one third of the data) were presented at the 71st American Diabetes Association Scientific Sessions in June 2011.

Funding Sources

The baseline examination of the Hispanic Community Health Study/Study of Latinos was carried out as a collaborative study supported by contracts from the National Heart, Lung, and Blood Institute (NHLBI) to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235), Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following NIH Institutes/Offices collaborated and co-funded the first phase of the study: the National Institute on Minority Health and Health Disparities, the National Institute on Deafness and Other Communication Disorders, the National Institute of Dental and Craniofacial Research, the National Institute of Diabetes and Digestive and Kidney Diseases, the National Institute of Neurological Disorders and Stroke, and the NIH Office of Dietary Supplements.

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Figure 1. Venn Diagram of the Distribution of Probable Diabetes Mellitus Glycemic Criteria

The percentages are based on the target population, $n = 15,507$.

Total FPG (2.3%) = FPG ≥ 7.1 mmol/L + any 2hPG + any HbA_{1c};

Isolated FPG (0.2%) = FPG ≥ 7.1 mmol/L + normal 2hPG + normal HbA_{1c}

FPG + 2hPG + other HbA_{1c} (0.2%) = FPG ≥ 7.1 mmol/L + 2hPG ≥ 11.2 mmol/L + HbA_{1c} within normal or pre-diabetes range;

FPG + HbA_{1c} + other 2hPG (1.3%) = FPG ≥ 7.1 mmol/L + HbA_{1c} ≥ 48 mmol/mol + 2hPG within normal or pre-diabetes range;

Total 2hPG (4.4%) = 2hPG ≥ 11.2 mmol/L + any FPG + any HbA_{1c};

Isolated 2hPG (3.0%) = 2hPG ≥ 11.2 mmol/L + normal FPG + normal HbA_{1c}

2hPG + HbA_{1c} + other FPG (0.6%) = 2hPG ≥ 11.2 mmol/L + HbA_{1c} ≥ 48 mmol/mol + FPG within normal or pre-diabetes range

Total HbA_{1c} 6.5% (3.3%) = HbA_{1c} ≥ 48 mmol/mol + any FPG + any 2hPG;

Isolated HbA_{1c} 6.5% (0.7%) = HbA_{1c} ≥ 48 mmol/mol + normal FPG + normal 2hPG

Total FPG + 2hPG + HbA_{1c} (0.6%) = FPG ≥ 7.1 mmol/L + 2hPG ≥ 11.2 mmol/L + HbA_{1c} ≥ 48 mmol/mol

Table 1.

Prevalence of unrecognized diabetes mellitus glycemic categories by sex-, age-, Hispanic/Latino heritage group, and distribution of anthropometric characteristics according to glycemic subcategories

		Among the entire target population (n = 15507)					
		Total Prevalence of Unrecognized Diabetes Mellitus	Total FPG 7.1 mmol/L	Total 2hPG 11.2 mmol/L	Total HbA _{1c} 48 mmol/mol (6.5%)	FPG 7.1 mmol/L + HbA _{1c} 48 mmol/mol (6.5%) + any 2hPG	FPG 7.1 mmol/L + 2hPG 11.2 mmol/L + HbA _{1c} 48 mmol/mol (6.5%)
N		1194	411	764	613	332	94
Prevalence (%)		6.7 (6.1–7.2) †	2.3 (2.1–2.7) †	4.4 (4.0–4.9)	3.3 (2.9–3.7) †	1.9 (1.7–2.2) †	0.6 (0.5–0.8)
Mean Age (years) (sexes combined)		43.7 (43.3–44.0)	43.1 (42.40–43.71)	44.2 (43.80–44.53)	43.5 (43.06–43.94)	43.3 (42.71–43.97)	43.2 (42.37–44.08)
Prevalence by Sex							
Men Age groups (years)	All	6.1 (5.4–7.0)	2.4 (2.0–2.9)	3.9 (3.3–4.5) *	3.1 (2.6–3.7)	1.9 (1.5–2.4)	0.5 (0.4–0.8)
	18–29	1.3 (0.8–2.2)	0.7 (0.3–1.3)	0.7 (0.3–1.5)	0.7 (0.4–1.2)	0.5 (0.2–1.0)	0.3 (0.1–0.7)
	30–39	2.7 (1.7–4.2)	1.3 (0.6–2.7)	1.4 (0.8–2.6)	1.4 (0.7–2.8)	1.2 (0.6–2.6)	0.2 (0.0–1.4)
	40–49	6.4 (5.0–8.2)	3.0 (2.2–4.2)	3.5 (2.5–5.0)	3.6 (2.6–5.0)	2.4 (1.6–3.5)	0.4 (0.2–0.8)
	50–59	8.6 (7.2–10.4)	3.4 (2.6–4.5)	5.8 (4.5–7.3)	4.5 (3.5–5.8)	2.4 (1.8–3.4)	0.9 (0.5–1.4)
	60–69	12.8 (9.9–16.4)	5.0 (3.2–7.9)	8.7 (6.6–11.3)	6.3 (4.2–9.4)	3.9 (2.3–6.7)	1.5 (0.7–3.1)
	70–74	14.1 (8.3–23.1)	1.8 (0.6–5.5)	10.0 (5.5–17.5)	5.2 (1.7–14.3)	1.4 (0.4–5.4)	0.0 (0.0)
Women Age groups (years)	All	7.1 (6.4–7.9)	2.3 (1.9–2.7)	4.9 (4.3–5.5) *	3.4 (2.9–4.0)	2.0 (1.6–2.4)	0.7 (0.4–1.0)
	18–29	1.2 (0.7–2.2)	0.3 (0.1–0.8)	0.8 (0.4–1.5)	0.6 (0.3–1.2)	0.3 (0.1–0.8)	0.1 (0.0–0.3)
	30–39	3.2 (2.1–4.7)	1.7 (1.0–2.7)	1.6 (0.9–2.8)	2.2 (1.4–3.4)	1.5 (0.9–2.5)	0.3 (0.1–1.1)
	40–49	7.8 (6.3–9.6)	3.8 (2.7–5.5)	4.4 (3.4–5.7)	4.5 (3.3–6.1)	3.3 (2.2–4.9)	0.9 (0.4–1.9)
	50–59	10.4 (9.0–12.1)	2.5 (1.9–3.3)	7.1 (5.8–8.6)	5.2 (4.2–6.4)	2.0 (1.5–2.8)	0.6 (0.3–1.0)
	60–69	13.1 (10.5–16.2)	3.4 (2.3–5.1)	10.4 (8.1–13.2)	5.1 (3.6–7.1)	3.2 (2.1–4.9)	1.3 (0.6–2.9)
	70–74	19.8 (13.4–28.3)	3.5 (1.2–9.8)	17.2 (11.3–25.2)	6.1 (2.7–13.2)	3.3 (1.1–9.8)	2.8 (0.7–9.9)
Prevalence by Hispanic/Latino Heritage Group	Central American	7.7 (6.1–9.6)	2.6 (1.8–3.8)	5.5 (4.1–7.3)	3.4 (2.5–4.5)	2.1 (1.4–3.0)	0.7 (0.4–1.3)
	Cuban	6.1 (5.2–7.3)	1.6 (1.2–2.2)	4.7 (3.9–5.5)	2.6 (2.0–3.3)	1.4 (1.0–1.9)	0.6 (0.4–1.0)
	Dominican	5.8 (4.6–7.3)	1.6 (1.0–2.5)	3.9 (2.9–5.3)	2.5 (1.8–3.6)	1.3 (0.8–2.1)	0.2 (0.1–0.5)
	Mexican	7.2 (6.1–8.4)	2.7 (2.1–3.4)	4.5 (3.8–5.3)	3.7 (3.0–4.6)	2.2 (1.7–3.0)	0.6 (0.3–1.0)

Among the entire target population (n = 15507)						
		Total Prevalence of Unrecognized Diabetes Mellitus	Total FPG mmol/L	Total 2hPG mmol/L	Total HbA _{1c} 48 mmol/mol (6.5%)	FPG 7.1 mmol/L + 2hPG 11.2 mmol/L + HbA _{1c} 48 mmol/mol (6.5%)
BMI	Puerto Rican	5.4 (4.5–6.6)	2.1 (1.5–2.9)	3.5 (2.7–4.4)	3.0 (2.4–3.7)	0.6 (0.3–1.0)
	South American	5.7 (4.3–7.5)	1.4 (0.8–2.3)	4.3 (3.0–6.1)	1.9 (1.1–3.2)	0.3 (0.1–1.3)
	25.0 (%)	3.66 (2.88, 4.64)	1.22 (0.80, 1.84)	2.68 (2.00, 3.59)	1.10 (0.73, 1.66)	0.06 (0.01, 0.24)
	25–29.9 (%)	5.64 (4.91, 6.48)	1.82 (1.42, 2.34)	3.82 (3.24, 4.50)	2.42 (1.94, 3.01)	0.37 (0.21, 0.68)
Family History	30.0 (%)	8.89 (7.96, 9.92)	3.25 (2.72, 3.89)	5.80 (5.10, 6.59)	4.90 (4.23, 5.66)	1.05 (0.75, 1.48)
	Yes (%)	7.70 (6.83, 8.68)	2.76 (2.28, 3.34)	4.85 (4.20, 5.60)	4.02 (3.43, 4.71)	0.77 (0.51, 1.18)
	No (%)	5.69 (5.10, 6.35)	1.74 (1.41, 2.14)	4.20 (3.69, 4.78)	2.45 (2.07, 2.90)	0.48 (0.32, 0.72)
	Born in U.S. Mainland	3.47 (2.72, 4.43)	1.41 (0.97, 2.04)	1.96 (1.40, 2.72)	2.25 (1.62, 3.11)	0.42 (0.18, 0.96)
Place of birth and years living in the U.S. (%)	Born Outside of U.S. Mainland					
	0–5 years	6.61 (5.13, 8.49)	1.95 (1.23, 3.09)	5.38 (4.07, 7.07)	2.67 (1.78, 3.98)	1.09 (0.53, 2.24)
	6–10 years	6.72 (5.37, 8.38)	2.16 (1.41, 3.30)	4.66 (3.49, 6.20)	3.25 (2.27, 4.62)	0.94 (0.46, 1.92)
	11–15 years	6.34 (5.13, 7.82)	2.57 (1.76, 3.72)	3.92 (2.93, 5.21)	3.33 (2.48, 4.45)	0.41 (0.18, 0.91)
	16+ years	7.07 (6.29, 7.94)	2.40 (1.94, 2.98)	4.54 (3.99, 5.16)	3.47 (2.88, 4.17)	0.38 (0.26, 0.54)

Data were weighted and are presented as means or percentage and 95% CI in parentheses. Percentages are based on the target population (n = 15,507)

Total prevalence = FPG 7.1 mmol/L and/or 2hPG 11.2 mmol/L and/or HbA_{1c} 48 mmol/mol (6.5%)

Total FPG = FPG 7.1 mmol/L + any 2hPG + any HbA_{1c}

Total 2hPG = 2hPG 11.2 mmol/L + any FPG + any HbA_{1c}

Total HbA_{1c} = HbA_{1c} 48 mmol/mol (6.5%) + any FPG + any 2hPG

Total FPG + HbA_{1c} = FPG 7.1 mmol/L + HbA_{1c} 48 mmol/mol (6.5%) + (any 2hPG)

* p-value < 0.05 was considered statistically significant when sexes were compared.

† p-value < 0.05 was considered statistically significant when Hispanic/Latino heritage groups were compared.

Sensitivity and specificity values of FPG, HbA_{1c}, and the combination of FPG and HbA_{1c} in the target population using 2hPG as the gold standard

Table 2.

	FPG vs. 2hPG		HbA _{1c} vs. 2hPG		FPG+HbA _{1c} vs. 2hPG	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
All	18.7 (15.2, 22.8)	99.7 (99.6, 99.8)	28.3 (24.1, 32.8)	99.3 (99.1, 99.5)	33.0 (28.8, 37.5)	99.1 (98.9, 99.3)
Age						
18–44 yr.	18.8 (11.5, 29.1)	99.7 (99.6, 99.8)	16.0 (10.0, 24.1)	99.6 (99.4, 99.7)	21.2 (14.8, 29.6)	99.4 (99.2, 99.5)
45–64 yr.	19.2 (15.1, 24.1)	99.7 (99.5, 99.8)	34.7 (29.1, 40.7)	98.8 (98.3, 99.1)	39.0 (33.6, 44.7)	98.5 (98.1, 98.9)
65–74 yr.	17.4 (10.5, 27.3)	99.7 (99.4, 99.9)	26.3 (17.5, 37.4)	99.2 (98.3, 99.6)	31.2 (22.2, 42.0)	99.0 (98.0, 99.5)
Sex						
Men	22.8 (17.7, 28.9)	99.6 (99.5, 99.8)	28.1 (22.5, 34.5)	99.3 (99.1, 99.5)	35.1 (29.3, 41.4)	99.1 (98.8, 99.2)
Women	15.8 (11.8, 20.9)	99.8 (99.7, 99.8)	28.3 (23.5, 33.8)	99.3 (99.1, 99.5)	31.6 (26.6, 36.9)	99.2 (99.0, 99.4)
BMI category						
<25 kg/m ²	10.3 (4.7, 21.3)	99.8 (99.6, 99.9)	5.0 (2.4, 9.8)	99.9 (99.8, 99.9)	11.9 (6.5, 20.7)	99.7 (99.5, 99.8)
25.0–29.9 kg/m ²	12.6 (8.2, 18.9)	99.8 (99.6, 99.9)	19.7 (14.4, 26.3)	99.5 (99.2, 99.7)	22.9 (17.3, 29.6)	99.4 (99.1, 99.6)
30.0 kg/m ²	23.8 (19.1, 29.3)	99.5 (99.3, 99.7)	37.1 (31.4, 43.2)	98.8 (98.4, 99.0)	42.4 (36.9, 48.2)	98.5 (98.1, 98.8)

Table 3.

Weighted prevalence and adjusted prevalence ratios* (95% CI) of cardiovascular risk factors according to diabetes status category

	Prevalence of Cardiovascular Risk Factors				Prevalence Ratios		
	NGT	Prediabetes (any criteria)	Prediabetes (all 3 criteria)	Unrecognized Diabetes Mellitus	PR (95% CI) using NGT as reference	PR (95% CI) using Pre-diabetes (any criteria) as reference	PR (95% CI) using Pre-diabetes (all 3 criteria) as reference
Hypertension	15.5 (14.0, 17.2)	21.0 (19.0, 23.0)	34.3 (27.5, 41.8)	25.0 (20.5, 30.1)	1.16 (1.01–1.33)	1.08 (0.99–1.19)	0.92 (0.81–1.05)
Low HDL-C	37.6 (35.5, 39.8)	42.9 (40.8, 44.9)	50.3 (43.8, 56.8)	53.3 (47.7, 58.7)	1.32 (1.18–1.47)	1.21 (1.10–1.34)	1.11 (0.96–1.28)
High LDL-C	39.2 (36.9, 41.5)	45.1 (43.1, 47.2)	51.7 (44.5, 58.8)	52.2 (46.6, 57.7)	0.98 (0.85–1.13)	1.01 (0.90–1.13)	0.98 (0.84–1.14)
High TG	23.8 (21.7, 26.1)	33.5 (31.7, 35.4)	43.9 (37.0, 51.1)	49.7 (44.5, 54.9)	1.60 (1.39–1.84)	1.38 (1.25–1.53)	1.15 (0.98–1.36)
High UACR	5.7 (4.8, 6.8)	6.4 (5.6, 7.4)	8.6 (5.7, 12.6)	17.3 (13.4, 22.0)	3.24 (2.29, 4.56)	2.20 (1.74–2.78)	1.50 (1.06–2.13)
Obesity	30.0 (27.9, 32.2)	47.3 (45.2, 49.4)	63.3 (57.0, 69.2)	60.2 (55.4, 64.7)	1.99 (1.77, 2.24)	1.28 (1.18, 1.40)	1.01 (0.90, 1.14)

* All prevalence and prevalence ratios for cardiovascular risk factors were adjusted for age, sex, BMI, and Hispanic/Latino heritage group, except for obesity which was adjusted for age, sex, and Hispanic/Latino heritage group.