High Prevalence of Diabetes and Prediabetes and Their Coexistence with Cardiovascular Risk Factors in a Hispanic Community

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Abstract This study examined the prevalence and association of diabetes mellitus (DM) and prediabetes with cardiovascular risk factors among Puerto Ricans adults. Data from a household survey of 857 adults aged 21–79 years who underwent interviews, physical exams, and blood draws were analyzed. Prevalence of total DM and prediabetes was estimated using American Diabetes Association diagnostic criteria of fasting plasma glucose (FPG) and hemoglobin A1c (HbA1c). Poisson regression models were used to estimate the prevalence ratio for each cardiovascular risk factor under study. Age-standardized prevalence of total DM and prediabetes, detected by FPG and/or HbA1c, was 25.5 and 47.4 %, respectively. Compared with participants with normoglycemia, those with previously diagnosed DM, undiagnosed DM, and prediabetes had more adverse cardiovascular risk factor profiles, characterized by a higher prevalence of general and abdominal obesity, hypertension, low HDL cholesterol,

elevated LDL cholesterol, elevated triglycerides, and elevated plasminogen activator inhibitor 1 ($p < 0.05$). The high prevalence of DM and prediabetes calls for public health actions to plan and implement lifestyle interventions to prevent or delay the onset of DM and cardiovascular disease.

Keywords Diabetes · Prediabetes · Undiagnosed diabetes · Cardiovascular risk factors · Puerto Rico

Introduction

The burden of diabetes mellitus (DM) and prediabetes vary substantially among racial/ethnic groups in the United States (US), with American Indians having the highest prevalence of type 2 DM [1]. The number of individuals with diagnosed DM in the US is projected to increase by 198 % between 2005 and 2050; however, this increase will be largest for minority groups, especially Hispanics, where the number is projected to increase by 481 % [2, 3].

Even though the higher burden of type 2 DM among Hispanics has been widely documented in the US [4–6], there are limited data on the burden of these conditions across Hispanic subgroups. Puerto Ricans, the second largest Hispanic subgroup in the US, are disproportionately affected by DM and other cardiovascular risks factors compared to other ethnic groups [7, 8]. The Boston Puerto Rico Health Study has documented that Puerto Ricans are disproportionately affected by obesity and type 2 DM compared with non-Hispanic Whites [7]. More recently, data from the Hispanic Community Health Study/Study of Latinos, a multicenter community-based cohort study of Hispanics in the US, have shown that mainland Puerto Ricans experience the highest age- and sex-adjusted

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prevalence of adverse cardiovascular disease risk profile compared with Cubans, Dominicans, Mexicans, and Central and South Americans [8].

To date, data about the burden of DM and prediabetes and their coexistence with cardiovascular risk factors in Hispanics living in Puerto Rico are sparse. The Behavioral Risk Factor Surveillance Survey (BRFSS) has consistently shown that Puerto Rico has the highest age-adjusted prevalence and incidence of DM among US states and territories [9, 10]. However, these data are based on self-reports, thus captures only those individuals who have been diagnosed with DM. Burden of the metabolic syndrome and its individual components in Puerto Rico appears to be high [11], supporting the notion of the widespread risk of developing DM and cardiovascular disease. These data are of great concern because, contrary to the US where DM is the seventh leading cause of death [1], DM is ranked as the third-leading cause of death in Puerto Rico and has maintained its ranking over the past 20 years [12]. Moreover, the age-adjusted rate of treatment initiation for end-stage renal disease attributed to DM among persons with DM in Puerto Rico increased from 1996 to 2006, contrary to all US regions and in most states, where the age-adjusted rate declined during this time period [13].

Understanding the prevalence of DM and prediabetes is essential for policy development and for planning prevention and control public health programs. To start addressing this gap in knowledge, we characterized the prevalence of diagnosed and undiagnosed DM and prediabetes and assessed their associations with cardiovascular risk factors in an adult population living in Puerto Rico.

Methods

Study Population

We performed a secondary data analysis of a household survey that covered the civilian, non-institutionalized adult population living in the San Juan metropolitan area, a geographical area that includes seven municipalities of Puerto Rico. Detailed description of the study design and recruitment has been published previously [11, 14]. The sampling frame was based on the maps of the San Juan metropolitan area census tracts, and the sampling procedure was a cluster design for household surveys. A three-stage sampling design was used. The first stage consisted of the random selection of groups of blocks using a systematic design, where the groups of blocks were sorted by their median housing value and weighted by the number of potential area segments of 12 consecutive households in each block. The second stage consisted of the random selection of a single block from each block group. Each

selected block was visited to enumerate the actual number of households within area segments. The random selection of one area segment per block was the third stage of sample selection.

Eligibility criteria included individuals aged 21–79 years, except those who were pregnant or had a health status that did not allow them to complete or understand one or more aspects of the informed consent form. All eligible individuals who agreed to participate in the study were instructed to fast for 8–12 h prior to attend their appointment in a mobile examination unit located near their homes between 6:00 and 9:00 a.m. Study procedures included a face-to-face interview, anthropometric measurements, blood pressure readings, and blood draw for laboratory testing. Of 1,200 eligible adults, 867 (72.3 %) participated in all study procedures. Ten participants were excluded because they had missing data needed to define DM status, thus the final analytic sample included 857 participants. This study was approved by the Institutional Review Board of the University of Puerto Rico Medical Sciences Campus. Informed consent was obtained from all subjects prior to their participation in the study.

Anthropometric measurements were taken in duplicate following the NHANES III Anthropometry Procedures Manual, and the average of the two measures was used. Standing height and weight were measured with the participants wearing light clothes and no shoes. Body mass index (BMI), defined as weight in kilograms divided by height in meters squared, was categorized as underweight/normal (≤ 24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30.0 kg/m²). Waist circumference (WC) was determined with a measuring tape at the high point of the iliac crest at minimal respiration. Elevated WC was defined as ≥ 40 inches in men and ≥ 35 inches in women, whereas elevated waist-to-hip ratio (WHR) was defined as >0.85 for men and >0.90 for women. Three blood pressure measurements were taken using a standard aneroid sphygmomanometer and an appropriate cuff size, and the average was used for analysis.

Blood was drawn to determine concentrations of HDL cholesterol (HDL-C), triglycerides, fasting plasma glucose (FPG), and hemoglobin A1c (HbA1c), using commercial enzymatic colorimetric kits (Bayer Diagnostics, Tarrytown, NY). LDL cholesterol (LDL-C) was estimated indirectly with the Friedewald equation in individuals with triglycerides <400 mg/dL. The high-sensitivity C reactive protein (hs-CRP) was measured using the ultrasensitive assay (Kamiya Biomedical, Seattle, WA). Plasminogen activator inhibitor 1 (PAI-1) levels were determined by the use of Imubind enzyme-linked immunosorbent assay (American Diagnostica Inc., Stamford, CT). A two site immunoassay for measuring human fibrinogen in plasma was used (DiaPharma Group Inc., West Chester, OH).

Diagnosed DM was determined on the basis of responses to the question “Other than during pregnancy, have you ever been told by a doctor that you have diabetes?”. The American Diabetes Association criteria [15] were used to classify study participants without a prior diagnosis of DM as having undiagnosed DM if they had a FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %; impaired fasting glucose (IFG) if they had a FPG of 100–125 mg/dL independent of HbA1c levels; impaired HbA1c if they had an HbA1c of 5.7–6.4 % independent of FPG levels; and total prediabetes if they had IFG and/or impaired HbA1c. Total DM was determined by the sum of diagnosed and undiagnosed cases.

Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg, diastolic blood pressure (DBP) ≥ 90 mm Hg, or self-reported current antihypertensive medications [16]. Dyslipidemia was defined as triglycerides ≥ 150 mg/dL, HDL-C < 40 mg/dL, LDL-C ≥ 160 mg/dL, or current use of lipid modification therapy [17]. Upper quartiles were used to define high levels of hs-CRP (>0.67 mg/L), PAI-1 (>18 ng/L), and fibrinogen (>350 mg/L).

Participants were considered current smokers if they responded “yes” to the questions “Have you ever smoked at least 100 cigarettes during your lifetime” and “Do you currently smoke?”. Former smokers were defined as those who had previously smoked at least 100 cigarettes in their lifetime and have stopped smoking. The remaining participants were classified as never smokers. Light-to-moderate drinkers were men that consumed no more than two drinks per day and women that consumed no more than one drink per day. Individuals that reported an alcohol intake that exceeded the American Dietary Guidelines cutoff points were classified as heavy drinkers. Individuals who reported participation in moderate-intensity activities for a minimum of 30 minutes on 5 days per week or vigorous-intensity activity for a minimum of 20 minutes on 3 days per week were classified as meeting physical activity national guidelines. Participants were categorized as meeting the national recommendations of fruits and vegetables if they reported eating at least five servings per day.

Statistical Analysis

Weighted prevalence of DM and prediabetes was estimated taking into account the probabilities of selection of the complex sampling design used in the study. Prevalence was age-standardized by the direct method to the 2000 US Census population using age groups 21–39, 40–59, and 60–79 years. Adjusted Wald test was used to assess gender differences in the prevalence of DM and prediabetes.

Table 1 Sociodemographic, health behaviors, and clinical characteristics of participants (n = 857)

Characteristic	Mean $\pm$ SD or %
Mean age, years	49.4 $\pm$ 16.1
Female gender (%)	65.7
Educational attainment (%)	
Less than high school	28.4
High school/Some college	42.9
College or more	28.7
Annual income $<$ \$20,000 (%)	67.2
Health insurance (%)	
Private	39.2
Medicare	15.3
Public	34.4
None	11.1
Tobacco use (%)	
Never smokers	61.2
Former smokers	18.8
Current smokers	20.0
Alcohol consumption (%)	
None	69.7
Light-to-moderate	10.1
Heavy	20.2
Lack of moderate-to-vigorous physical activity (%)	61.3
Daily servings of fruits and vegetables <5	93.8
Mean BMI, kg/m ²	29.7 $\pm$ 6.6
BMI (%)	
<25.0	22.4
25.0–29.9	36.8
≥ 30.0	40.8
Mean WC, inches	36.6 $\pm$ 5.8
Elevated WC (%)	48.7
Mean WHR	0.9 $\pm$ 0.1
Elevated WHR (%)	50.8
Mean SBP (mm Hg)	120.1 $\pm$ 21.1
Mean DBP (mm Hg)	72.9 $\pm$ 11.1
Hypertension (%)	39.3
Mean HDL-C, mg/dL	49.4 $\pm$ 13.0
HDL-C < 40 mg/dL (%)	20.7
Mean LDL-C, mg/dL	117.6 $\pm$ 39.1
LDL-C ≥ 160 mg/dL (%)	23.6
Mean triglycerides, mg/dL	141.8 $\pm$ 106.5
Triglycerides ≥ 150 mg/dL (%)	31.2
hs-CRP > 0.67 mg/L (%)	25.0
Fibrinogen > 365 mg/L (%)	25.3
PAI-1 > 18 ng/L (%)	28.1
Family history of DM (%)	49.6

Table 2 Weighted and age-standardized prevalence of diagnosed, undiagnosed, and total DM and prediabetes, based on FPG and HbA1c criteria, by sex, San Juan metropolitan area, Puerto Rico, 2005–2007

	All	Men	Women	<i>p</i> Value ^a
<i>Weighted prevalence</i>				
Diagnosed DM	17.4 (2.7)	19.8 (4.4)	16.1 (2.4)	0.34
Undiagnosed DM ^b				
FPG ≥ 126 mg/dL	4.6 (1.1)	6.1 (1.9)	3.8 (1.1)	0.27
HbA1c ≥ 6.5 %	12.0 (2.1)	10.3 (3.0)	13.0 (2.7)	0.48
FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %	13.2 (2.3)	12.7 (3.7)	13.5 (2.7)	0.87
Total DM ^c				
FPG ≥ 126 mg/dL	22.1 (3.1)	25.9 (4.7)	19.9 (2.9)	0.16
HbA1c ≥ 6.5 %	29.5 (3.7)	30.1 (5.3)	29.1 (4.2)	0.86
FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %	30.6 (3.8)	32.5 (5.5)	29.5 (4.3)	0.62
Prediabetes ^d				
IFG	28.0 (3.1)	32.8 (4.5)	25.3 (3.0)	0.05
Impaired HbA1c	40.9 (2.7)	41.5 (3.5)	40.6 (3.3)	0.82
IFG and/or impaired HbA1c	47.2 (2.8)	49.1 (4.6)	46.1 (3.4)	0.59
<i>Age-standardized prevalence</i>				
Diagnosed DM	14.1 (2.5)	14.9 (3.9)	13.6 (2.0)	0.68
Undiagnosed DM ^b				
FPG ≥ 126 mg/dL	4.1 (0.9)	5.3 (1.4)	3.5 (1.1)	0.29
HbA1c ≥ 6.5 %	10.3 (1.9)	8.5 (2.5)	11.3 (2.5)	0.41
FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %	11.4 (2.1)	11.1 (3.2)	11.7 (2.5)	0.88
Total DM ^c				
FPG ≥ 126 mg/dL	18.2 (2.8)	20.2 (4.1)	17.1 (2.5)	0.40
HbA1c ≥ 6.5 %	24.3 (3.2)	23.4 (4.5)	24.9 (3.4)	0.76
FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %	25.5 (3.3)	26.0 (4.5)	25.3 (3.4)	0.88
Prediabetes ^d				
IFG	26.7 (3.1)	32.7 (4.6)	23.9 (3.0)	0.04
Impaired HbA1c	41.0 (3.0)	43.2 (3.8)	40.1 (3.4)	0.46
IFG and/or impaired HbA1c	47.4 (3.1)	50.2 (4.5)	46.1 (3.6)	0.43

^a *p* value for adjusted Wald test for gender differences^b Undiagnosed DM was defined as FPG ≥ 126 mg/dL (independent of HbA1c levels); HbA1c ≥ 6.5 % (independent of FPG levels); and FPG ≥ 126 mg/dL and/or HbA1c ≥ 6.5 %^c Total DM was determined by the sum of diagnosed and undiagnosed cases^d Prediabetes was defined as IFG independent of HbA1c; impaired HbA1c independent of FPG; and IFG and/or impaired HbA1c

Poisson regression models with robust variance were used to estimate the prevalence ratio (PR) and its 95 % confidence interval (95 % CI) for cardiovascular risk factors under study. The associations of diagnosed DM, undiagnosed DM, total DM, and prediabetes, determined by FPG and/or HbA1c, with the cardiovascular risk factors

were explored in separate regression models adjusting for sex, educational attainment, smoking status, alcohol consumption, physical activity, and family history of DM. To assess confounding, covariates were entered into each model one at a time and compared unadjusted and adjusted PR estimates. Those covariates that altered the unadjusted PR by at least 10 % were considered confounders and thus retained in the multivariable model [18]. No interaction terms were statistically significant, thus the multivariable model contained only the main effects. All statistical analyses were performed using Stata for Windows (release 12.0, StataCorp, College Station, Texas) to account for the complex sampling design.

Results

Study participants had a mean age of 49.4 ± 16.1 years, nearly two-thirds were women, and 71.6 % completed high school or more (Table 1). Twenty percent of participants were current smokers, 30.3 % reported alcohol consumption, 61.3 % did not meet physical activity recommendations, and the vast majority (93.8 %) did not adhere to daily fruit and vegetable intake recommendations. A significant proportion of adults were overweight or obese (77.6 %) and had elevated WC (48.7 %) and WHR (50.8 %). Nearly 40 % of study subjects had hypertension, 20.7 % had reduced HDL-C, 31.2 % had elevated triglycerides, over a quarter had elevated levels of hs-CRP, fibrinogen, and PAI-1, and nearly half reported a family history of DM.

Prevalence of Diagnosed DM

Weighted prevalence of diagnosed DM determined by self-report on the face-to-face interview was 17.4 %, whereas age-standardized prevalence was lower (14.1 %) (Table 2). No differences in prevalence were found by sex.

Prevalence of Undiagnosed DM

The weighted prevalence of undiagnosed DM based on FPG criterion (independent of HbA1c) was 4.6 % (Table 2). However, prevalence based on HbA1c criterion (independent of FPG) was 12 %, approximately 2.6 times higher than the estimate based on FPG. The combined prevalence of undiagnosed DM, detected by FPG and/or HbA1c, was 13.2 %. Age-standardized prevalence estimates of undiagnosed DM (4.1, 10.3, and 11.4 %, respectively) were lower than weighted estimates. No significant differences were noted between men and women in the weighted and age-standardized prevalence of undiagnosed DM.

Table 3 Multivariable-adjusted prevalence ratios (PR)^a for individual cardiovascular risk factors in relation to diagnosed, undiagnosed, and total DM and prediabetes

Cardiovascular risk factor	Diagnosed DM PR (95 % CI)	Undiagnosed DM ^b PR (95 % CI)	Total DM ^c PR (95 % CI)	Prediabetes ^d PR (95 % CI)
Elevated BMI	1.82 (1.39–2.37)	1.39 (1.23–1.56)	1.62 (1.38–1.90)	1.71 (1.32–2.22)
Elevated WC	1.75 (1.41–2.17)	1.38 (1.24–1.55)	1.61 (1.38–1.87)	1.85 (1.44–2.37)
Elevated WHR	1.62 (1.34–1.94)	1.26 (1.14–1.38)	1.44 (1.26–1.66)	1.31 (1.04–1.66)
Hypertension	2.00 (1.61–2.50)	1.31 (1.12–1.52)	1.63 (1.33–2.01)	2.01 (1.37–2.94)
Low HDL-C	1.84 (1.10–3.07)	1.36 (1.12–1.64)	1.60 (1.24–2.07)	1.51 (1.06–2.16)
Elevated LDL-C	1.25 (0.97–1.60)	1.46 (1.21–1.77)	1.73 (1.33–2.27)	1.85 (1.17–2.94)
Elevated triglycerides	1.61 (1.15–2.26)	1.46 (1.24–1.72)	1.75 (1.38–2.20)	1.70 (1.18–2.45)
Elevated hs-CRP	1.95 (1.32–2.88)	1.40 (1.20–1.63)	1.63 (1.31–2.03)	1.31 (0.91–1.87)
Elevated fibrinogen	1.65 (1.14–2.38)	1.09 (0.89–1.34)	1.36 (1.06–1.75)	1.44 (1.01–1.29)
Elevated PAI-1	1.52 (1.03–2.24)	1.53 (1.34–1.74)	1.73 (1.42–2.11)	1.66 (1.19–2.32)

^a Prevalence ratios, with the normal glucose group as reference, adjusted for age, sex, educational attainment, smoking status, alcohol consumption, physical activity, and family history of DM

^b Undiagnosed DM was defined as FPG $\geq$ 126 mg/dL and/or HbA1c $\geq$ 6.5 %

^c Total DM was determined by the sum of diagnosed and undiagnosed cases

^d Prediabetes was defined as IFG and/or impaired HbA1c

Prevalence of Total DM

The weighted prevalence of total DM based on FPG criterion (independent of HbA1c) was 22.1 %; however, when HbA1c criterion (independent of FPG) was used, the prevalence increased to 29.5 % (Table 2). The combined prevalence of total DM, detected by FPG and/or HbA1c, was 30.6 %. Age-standardized prevalence estimates of total DM (18.2, 24.3, and 25.5 %, respectively) were lower than weighted estimates, and no significant differences were noted between men and women.

Prevalence of Prediabetes

Prevalence of IFG was 28 %, whereas impaired HbA1c was found in 40.9 % of participants, about 1.5 times the prevalence of IFG. The weighted prevalence of total prediabetes, either IFG and/or impaired HbA1c, was 47.2 %. Age-standardized prevalence estimates of IFG, impaired HbA1c, and total prediabetes were lower (26.7, 41.0, and 47.4 %, respectively) than weighted estimates. While no significant differences were noted between men and women in the weighted and age-standardized prevalence of impaired HbA1c and total prediabetes, the age-standardized prevalence of IFG was significantly higher in men than in women (32.7 vs. 23.9 %, $p = 0.04$).

Prevalence of Cardiovascular Risk Factors in Subjects with Diagnosed DM, Undiagnosed DM, and Prediabetes

With only a few exceptions, the patterns of associations of measured cardiovascular risk factors with diagnosed DM,

undiagnosed DM, total DM, and prediabetes, determined by FPG and/or HbA1c criteria, were consistent (Table 3). Compared with the normal glucose group, participants with previously DM had significantly ($p < 0.05$) higher adjusted prevalence of all cardiovascular risk factors, except for elevated LDL-C that reached borderline statistical significance ($p = 0.08$). Participants with undiagnosed DM also had a significantly ($p < 0.05$) higher adjusted prevalence of all the measured cardiovascular risk factors except elevated fibrinogen. For total DM, the associations remained significant ($p < 0.05$) for all cardiovascular risk factors. With the exception of elevated hs-CRP, individuals with prediabetes also had significantly ($p < 0.05$) greater prevalence of all cardiovascular risk factors than those with normoglycemia.

Discussion

This community-based study of Hispanic adults living in the San Juan Metropolitan Area of Puerto Rico concurrently examined the prevalence of total DM (diagnosed and undiagnosed) and prediabetes, and their coexistence with cardiovascular risk factors. Age-standardized prevalence of total DM and prediabetes, detected by FPG and/or HbA1c, were 25.5 and 47.4 %, respectively, higher estimates than the reported prevalence for US adults (11.3 % in age group ≥ 20 years in 2010 and 36.2 % in age group ≥ 20 years in 2007–2010, respectively) [1, 19]. Prevalence of total DM was also considerably higher than that found in seven urban Latin American cities (7 %) [20] and eight countries in Latin America (5 %) [21]. Although the reasons for the relatively

higher prevalence of total DM and prediabetes among Puerto Ricans are unclear, these variations may reflect differences in sampling strategies and heterogeneity of laboratory assay performance employed for glucose determination in the different population-based studies. However, these variations may also reflect the greater prevalence of DM risk factors and medical comorbidities in islander Puerto Ricans [11]. In agreement with previous reports, a recent study suggests that Puerto Rico is undergoing a nutrition transition similar to those in resource-poor countries where choices are limited by income and physical access to nutrient-rich foods [22]. Another study conducted among college students showed that most individuals (62 %) had diets that were below the dietary recommendations for grains, fruits, vegetables, dairy products, and proteins [23]. These findings are in line with the 2010 BRFSS data showing that Puerto Rico ranked 7th in the US in the prevalence of hypertension and in the bottom 10 on various health indicators, including overweight and obesity, daily fruit and vegetable intake, and physical inactivity [24]. Further, 45 % of Puerto Ricans lived in poverty based upon family income Census data [25], condition that has been linked to unhealthy behaviors and chronic disease burden. These data underscore the need for heightening awareness of hyperglycemic conditions among high-risk populations and healthcare providers and for implementing effective interventions to delay or prevent the onset of DM and related complications.

Applying HbA1c criterion to define undiagnosed DM, total DM, and prediabetes in the present study resulted in higher age-adjusted prevalence of these conditions than with FPG. These findings contrast to the results from several studies that have shown that the use of HbA1c criteria result in lower prevalence of total DM and prediabetes compared with estimates based on glucose assays [26, 27]. However, the results of the present study are comparable to several international studies that have shown considerable discordance between FPG- and HbA1c-based diagnosis of hyperglycemic conditions that is accentuated by race and ethnicity, possibly reflecting biologic variation in hemoglobin glycation or red cell survival [26, 28–30]. The American Diabetes Association has also indicated that this discordance may be attributed to measurement variability or to the different pathophysiologic mechanisms of abnormal glucose homeostasis that are measured by FPG, 2-h postprandial glucose, and HbA1c measures [15]. Further clinical and epidemiological studies are warranted to shed light on the performance of these assays, especially among ethnic minorities.

The excess prevalence of traditional and non-traditional cardiovascular risk factors in participants with DM (diagnosed and undiagnosed) and prediabetes in this population concurs with previous epidemiologic data supporting the notion that alterations in glucose homeostasis are

associated with a clustering of metabolic and thrombotic/hemostatic risk factors which increase the risk for cardiovascular disease. For example, a meta-analysis of 698,782 people showed that DM confers about a twofold excess risk for a wide range of vascular diseases, independently from lipid, inflammatory, or renal markers; however, this study showed much more moderate associations of IFG status with coronary heart disease and stroke [31]. Although the exact magnitude of the risk for cardiovascular disease associated with IFG remains unknown, a meta-analysis of 52,994 participants with information about IFG showed a modest increase in cardiovascular risk (RR 1.18, 95 % CI 1.09–1.28) after adjusting for age, smoking status, blood pressure, and lipids [32]. Thus, the adverse cardiovascular risk factor profile among individuals with DM and prediabetes observed in this study supports the urgent need to implement culturally competent interventions to reduce the risk of progression of prediabetes to DM and of its microvascular and macrovascular complications.

The present study provided the opportunity to describe an understudied ethnic group using a strong epidemiologic design that achieved a good response rate (72.3 %) and that incorporated anthropometric and biologic measurements for the adequate identification of clinical variables [11, 14]. Nevertheless, some limitations deserve mention. First, previously diagnosed DM was based on self-report, thus misclassification might occur as a result of recall error. Second, determination of prediabetes and undiagnosed DM was based on single measurements of HbA1c and FPG since 2-hour postprandial glucose test results were not available. Given the cross-sectional nature of the study, observed associations between DM and prediabetes and cardiovascular risk factors cannot be temporarily linked. As with most observational studies, the possibility of residual confounding cannot be excluded. Finally, caution must be exercised in interpreting these results as generalizable to the adult population aged 21–79 years in Puerto Rico, as results pertain to the population living in the seven municipalities that constitute the San Juan Metropolitan Area of Puerto Rico.

Conclusion

Given the high mortality burden imposed by DM on Puerto Rico's health care system, the high prevalence of DM and prediabetes and the adverse cardiovascular disease risk profile observed in this study support the urgent need to enhance the public health surveillance to support the planning and implementation of prevention programs. Despite it may be difficult to disentangle all explanations for the large burden of DM and prediabetes observed in this

population, these data provide useful information which underscores the need to further research the extent to which behavioral, environmental, genetic, social, and structural exposures are responsible for the large prevalence of hyperglycemic conditions.

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