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Ethnic differences in prediabetes and diabetes in the Suriname Health Study

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ABSTRACT

Background: Diabetes is increasing worldwide, and information on risk factors to develop targeted interventions is limited. Therefore, we analyzed data of the Suriname Health Study to estimate the prevalence of prediabetes and diabetes. We also explored whether ethnic differences in prediabetes or diabetes risk could be explained by biological, demographic, lifestyle, anthropometric, and metabolic risk factors.

Method: The study was designed according to the WHO Steps guidelines. Fasting blood glucose levels were measured in 3393 respondents, aged 15–65 years, from an Amerindian, Creole, Hindustani, Javanese, Maroon or Mixed ethnic background. Prediabetes was defined by fasting blood glucose levels between 6.1 and 7.0 mmol/L and diabetes by fasting blood glucose levels ≥7.0 mmol/L or 'self-reported diabetes medication use.' For all ethnicities, we analyzed sex, age, marital status, educational level, income status, employment, smoking status, residence, physical activity, body mass index, waist circumference, hypertension, and the levels of triglyceride, total cholesterol, high-density lipoprotein-cholesterol and low-density lipoprotein-cholesterol.

Results: The prevalence of prediabetes was 7.4%, while that of diabetes was 13 0%. From these diabetes cases, 39.6% were not diagnosed previously. No ethnic differences were observed in the prevalence of prediabetes. For diabetes, Hindustanis (23.3%) had twice the prevalence compared to other ethnic groups (4.7–14.2%). The associations of the risk factors with prediabetes or diabetes varied among the ethnic groups. The differences in the associations of ethnic groups with prediabetes or diabetes were partly explained by these risk factors.

Conclusions: The prevalence of diabetes in Suriname is high and most elevated in Hindustanis. The observed variations in risk factors among ethnic groups might explain the ethnic differences between these groups, but follow-up studies are needed to explore this in more depth.

Key messages

- The prevalence of diabetes in Suriname has reached epidemic levels (13.0%), with the highest prevalence in Hindustanis (23.3%).
- More than one-third (39.6%) of the participants with diabetes were not diagnosed previously.
- Demographic, lifestyle, anthropometric, and metabolic risk factors play an important role in differences in the prevalence of diabetes between ethnic groups.

INTRODUCTION

Globally, about 382 million individuals are diagnosed with diabetes mellitus, and this number will increase to over 430 million by 2030.[1] It is expected that the burden of disease will increase primarily in developing countries.[2] Preventable risk factors such as obesity and a sedentary lifestyle, combined with irreversible factors as ageing, seem to be the main cause of the expected increase.[2–4] Furthermore, various studies have indicated strong associations of hypertension and dyslipidemia with diabetes.[5–8] The prevalence of prediabetes, a condition with fasting blood glucose levels between normal and that of diabetes,[9] is expected to increase. Over a 10-year period, the estimated risk to progress from prediabetes to diabetes was 50%.[10]

Ethnic differences in the prevalence of diabetes have been reported in several countries.[11–14] Studies in the UK, the USA, Norway and the Netherlands have reported a higher diabetes prevalence in Asians, Africans and their descendants compared to whites.[15] However, limited information is available on the association between the risk factors and ethnicity in developing countries.

The Republic of Suriname, located in the northeast of South America, is an upper-middle income country with a multicultural and multiethnic population, mainly of African, Indian and Indonesian descent.[16] Diabetes is the 4th principal cause of death in Suriname[17] and limited information is available on the distribution of risk factors among ethnic groups. A previous study has reported a prevalence of 10% of diabetes,[18] with a higher prevalence in Hindustanis compared to other ethnicities.

We used data from the Suriname Health Study, the first nationwide study on non-communicable disease risk factors,[19] to

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estimate the prevalence of prediabetes and diabetes as well as to assess the main risk factors in different ethnic subgroups. We also explored whether ethnic differences in the risk for diabetes could be explained by biological, demographic, lifestyle, anthropometric and metabolic risk factors.

METHODS

Design

We used data from the Suriname Health Study,[19] which was designed according to the WHO Steps guidelines[20] and was formally approved by the Ethics Committee of the Ministry of Health (Commissie Mensgebonden Wetenschappelijk Onderzoek (reference VG 004-2013)). Suriname has ~550 000 inhabitants, categorized into 15.7% Creole (descendants of African plantation slaves), 27.4% Hindustani (descendants from Indians), 13.7% Javanese (descendants from Indonesians), 21.7% Maroon (descendants of African refugees who escaped slavery and formed independent settlements in the hinterland), 13.4% Mixed, 7.6% others including Amerindians (original inhabitants) and 0.6% unknown.[16] Through history, Creoles, Hindustanis and Javanese inhabited the urban and rural coastal areas, whereas the rural interior is inhabited by Amerindians and Maroons, both living in isolated villages in primitive settings.[21]

As described previously, this study used a stratified multistage cluster sample of households to select respondents between March and September 2013. In total, 343 clusters were selected randomly within the enumeration areas of the 10 districts of Suriname. Except for the 16 clusters in district Sipaliwini, each cluster contained 25 households. The clusters in Sipaliwini contained 40 households due to the huge costs of transportation to the isolated villages in the tropical rainforest. In the selected households, the age and gender of everyone eligible for the survey were listed in a Kish selection grid. Subsequently, the respondent was identified using a preassigned table of random numbers.[22] Written informed consent was received from each participant.

We invited 7493 individuals between the age of 15 and 65 years to participate in this study. The response rate was 76.7%, resulting in 5748 participants, of which 3765 rendered blood samples for analysis (online supplementary figure S1 gives the participants' flow chart). Blood glucose, cholesterol and triglycerides were analyzed in full blood by a WASO 9001 2008 certified laboratory to ensure monitored quality control. A total of 3393 blood samples were analyzed. Blood samples collected after an overnight fast of 9 hours were used for the analysis of lipids and blood glucose (n=3279), while those collected after an overnight fast of 8 hours were only used for glucose analysis (n=114). Thus, blood glucose was measured in a total of 3393 samples.

The participating staff was trained extensively according to the WHO Steps manual.[20] The medical section of the research team reviewed the physical and biochemical measurements and provided advice or referred to the general practitioner in cases with an adverse outcome. The respondents received the written results of their physical and biochemical measures.

Main outcomes

In accordance with the WHO criteria, prediabetes was defined as fasting blood glucose levels between 6.1 and 7.0 mmol/L and diabetes as fasting blood glucose ≥7.0 mmol/L or self-reported use of antidiabetic medication.[23–25]

Risk factors

We administered questionnaires and clinical measurements to collect information. Participants were categorized into a specific ethnic group if at least 3 of the 4 grandparents were of the same ethnicity. Anybody else was categorized in the group of Mixed ethnicity. This classification has been used and described in detail previously.[19 26] On the basis of previously validated prediction models,[27] we considered several risk factors. Biological factors included sex and age. Demographic factors included residential area, marital status, educational level, income status and employment. The residential addresses were stratified to urban and rural coastal areas and the rural interior.[28] Marital status included regular and common law marriage. Educational level was divided into low (lower than primary school education), middle (middle or secondary education) or high (higher than middle or secondary education). Household income was classified as the income status quintile from the Ministry of Internal Affairs of Suriname in Surinamese dollars, SRD (US $1=3.35 SRD). The 1st quintile corresponded to the lowest income and the 5th to the highest. Owing to the small numbers in the 4th and the 5th quintiles, these two were combined in the analysis. Employment included working and studying participants. Lifestyle factors included cigarette smoking and physical activity (in metabolic equivalent of Task (MET) minutes). Self-reported daily smoking was classified as smoking. To measure physical activity, we used the global physical activity questionnaire (GPAQ). Physical activity was classified according to the WHO recommendations in groups <600 MET and ≥600 MET. Anthropometric factors included body mass index (BMI) and waist circumference (WC). Height was measured with the Seca213 stand-alone stadiometer, and the respondents were weighed with the Tanita HS302 Solar Scale. BMI was classified in the categories <23, 23–25, 25–27.5, 27.5–30 and >30, taking into account the WHO ethnic specific cut-off points for overweight and obesity.[29] WC was determined with the Seca 201 measuring tapes. We used the WHO WC cut-off values that are associated with substantially increased metabolic risk for (WC ≥88 cm for women and WC ≥102 cm for men).[30] Metabolic factors

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included blood pressure, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglyceride levels. Hypertension was defined as systolic blood pressure ≥140 mm Hg or diastolic pressure ≥90 mm Hg or current treatment with antihypertensive medication. On the basis of the Adult Treatment Panel III recommendations, we considered total cholesterol ≥6.2, LDL cholesterol ≥3 and triglycerides ≥1.7 mmol/L, levels as increased, and HDL cholesterol levels of ≤1.3 mmol/L as low.[31]

Statistical analysis

First, we assessed the distribution of risk factors overall and among ethnic groups (table 1). Second, we calculated the estimated prevalence of prediabetes, diagnosed and undiagnosed diabetes overall and by sex, age and ethnicity. The statistical significance of the ethnic differences, sex differences and age differences in prevalences was tested with the Pearson χ^2 test (see online supplementary table S1 and figure 1). Third, we used logistic regression models to examine the associations of various risk factors with prediabetes or diabetes. All models were adjusted for sex and age (table 2). Fourth, the association between ethnicity (Hindustanis as the reference group) and the prevalence of (1) prediabetes or diabetes (table 3) and (2) diabetes (table 4) separately was evaluated with six adjustment models. The first model comprised the basic multivariate model adjusted for the biological factors. In addition to this basic model 1, we adjusted for demographic factors in model 2; lifestyle factors in model 3; for anthropometric measures in model 4, BMI and WC were entered as categorical variables; for metabolic measures in model 5 (in this model, we entered blood pressure as categorical variables and all blood lipids as continuous variables); and we adjusted for all risk factors in model 6. The influence of risk factors in a model was explored by looking at the difference in OR for each ethnic group as compared to the Hindustanis (reference). We used weighted data for all analyses and considered statistical significance at p values<0.05. The sample weights included adjustment weights for sex, age and ethnicity. We used the statistical software Epi Info 3.2 and the Statistical Packages for Social Sciences (SPSS V.21.0) for analyses.

RESULTS

Participant characteristics

Table 1 presents the participant characteristics. We observed the highest mean blood glucose value in Hindustanis. For biological factors, the highest percentage of men was found in Creoles and the highest age in Javanese. Most high values for demographic factors were seen in Amerindians, with the exclusion of the highest percentage of participants living with a partner in Javanese and the highest percentage living in urban areas in Creoles. For lifestyle factors, the highest percentage of smokers was found in Creoles and the lowest percentage of people who met the required level of physical activity was in Maroons. The highest values for anthropometric factors were found in Amerindians and Hindustanis. Apart from the highest systolic blood pressure in Creoles, all other metabolic factors showed the highest values in Javanese.

Prevalence of prediabetes and diabetes

The overall estimated prevalence of prediabetes was 7.4% (95% CI 7.7% to 9.7%) and of diabetes was 13.0% (CI 12.8% to 14.4%). The prevalence of prediabetes in men was significantly higher compared to women, while no difference in sexes was observed for diabetes. The prevalence of diabetes increased from 2.1% in the youngest age group (15–25 years) to 32.1% in the oldest age group (55–64 years; see online supplementary table S1). Overall, 39.6% of the participants with diabetes were not diagnosed previously. Figure 1 shows the prevalence of prediabetes and diabetes (diagnosed and undiagnosed) for the six ethnic groups in both sexes. The difference in prevalence of prediabetes between ethnicities was not statistically significant (p>0.05). In contrast, the difference in the prevalence of diagnosed and undiagnosed diabetes between the ethnic groups was statistically significant (p<0.05). The prevalence of diabetes among Hindustanis (23.3%) was 1.7 to 4.9 times higher compared to other ethnic groups (4.8–14.1%). The highest prevalences of undiagnosed diabetes were observed in Amerindian men and Hindustani women while the highest prevalences of diagnosed diabetes were observed in Hindustani men and women. The sex differences in the prevalence of prediabetes in Mixed participants and of diagnosed and total diabetes in Javanese participants were significant (p<0.05). In the other ethnic groups, the differences between the prevalences of prediabetes or diabetes in men and women were not statistically significant.

Odds ratios of various risk factors for prediabetes or diabetes, overall and within different ethnic groups

In the overall population and all ethnic groups, table 2 shows no associations for sex and a positive association for age with prediabetes or diabetes. As age groups increased, the OR compared to 15–34-year-olds increased for prediabetes or diabetes. The steepest incline with age was observed among Javanese and Hindustanis and the lowest in Mixed and Creole people. Few associations were observed for demographic factors with prediabetes or diabetes. In the association with higher education, we observed reduced odds for Hindustanis and Maroons. For income, we found a negative association overall and in Hindustanis and a positive association in Creoles. In comparison to the urban coastal area, we observed a negative association with the rural interior areas, overall and in Amerindians. In the overall population, married people had reduced odds for prediabetes or diabetes compared to singles. For

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Table 1 Participant characteristics, overall and per ethnic group (n=3393)

	Overall n=3393	Amerindian n=274	Creole n=397	Hindustani n=886	Javanese n=515	Maroon n=809	Mixed n=454
Fasting blood glucose, mean (SD) mmol/L	5.8 (1.9)	5.8 (1.9)	5.5 (1.5)	6.3 (2.5)	5.8 (1.8)	5.3 (1.2)	5.7 (1.9)
Men % (95% CI)	48.5 (46.8 to 50.2)	33.1 (26.0 to 41.3)	57.1 (52.3 to 61.8)	54.6 (51,7 to 57.5)	51.3 (46.9 to 55.7)	39.9 (36.1 to 43.8)	45.2 (41.1 to 49,4)
Age, median (95% range)	35.0 (15.0–62.0)	35.0 (15.8–62.0)	35.0 (15.0–62.0)	37 (16.0–62.0)	40.0 (16–63)	29.0 (15.0–61.1)	31.0 (15.0–62.0)
Education % (95% CI)							
Low	53.9 (52 to 55.6)	79.7 (72.5 to 85.8)	39.4 (34.6 to 44.4)	54.3 (51.3 to 57.3)	53.2 (48.8 to 57.6)	71.5 (67.7 to 75)	35.6 (31.6 to 39.8)
Middle	27.3 (25.9 to 28.8)	16 (10.8 to 23.1)	30.3 (25.9 to 35.1)	28.4 (25.8 to 31.2)	33.1 (29.1 to 37.4)	18.4 (15.5 to 21.8)	33.6 (29.7 to 37.8)
High	18.8 (17.6 to 20.1)	4.2 (1.5 to 8.4)	30.3 (25.9 to 35.1)	17.3 (15.1 to 19.7)	13.6 (10.8 to 17)	10.1 (7.9 to 12.8)	30.8 (26.9 to 34.9)
Income % (95% CI)							
q1-lowest	34.6 (32.5 to 36.7)	61.7 (50.1 to 72.5)	26.7 (21.3 to 32.9)	29.9 (26.4 to 33.7)	24.2 (19.8 to 29.3)	55.5 (50.2 to 60.7)	21.4 (17 to 26.5)
q2	32.5 (30.5 to 34.6)	22.7 (14.2 to 33.7)	38 (31.7 to 44.4)	38.7 (34.9 to 42.6)	36.5 (31.3 to 42)	27.7 (23.3 to 32.7)	23.8 (19.2 to 29.1)
q3	14.5 (12.9 to 16.1)	3.9 (0.8 to 10.8)	18.9 (14.1 to 24.5)	17.9 (15.1 to 21.2)	17.3 (13.5 to 22)	6.3 (4.2 to 9.5)	17.9 (13.8 to 22.8)
q4 and q5-highest	18.5 (16.8 to 20.3)	11.7 (5.4 to 20.7)	16.5 (11.9 to 21.7)	13.5 (11 to 16.4)	21.9 (17.7 to 26.9)	10.4 (7.6 to 14.1)	36.9 (31.4 to 42.5)
Residential area % (95% CI)							
Urban coastal	75.6 (74.4 to 77.0)	33.1 (26 to 41.3)	86.8 (83.2 to 89.8)	84.6 (82.4 to 86.7)	75.5 (71.6 to 79.1)	58.3 (54.4 to 62.2)	88.2 (85.2 to 90.6)
Rural coastal	14.6 (13.6 to 15.8)	28.4 (21.4 to 36.1)	13.2 (10.2 to 16.8)	15.4 (13.3 to 17.6)	24.5 (20.9 to 28.4)	6.9 (5.1 to 9.2)	11.6 (9.1 to 14.5)
Rural interior	9.9 (8.5 to 10.9)	38.5 (30.8 to 46.6)	0 (0 to 1.1)	0 (0 to 0.4)	0 (0 to 0.9)	34.8 (31.1 to 38.6)	0.3 (0 to 1.3)
Living with partner % (95% CI)	51.4 (49.7 to 53.1)	67.3 (59.3 to 74.6)	27.5 (23.4 to 32.1)	62.7 (59.8 to 65.5)	73.2 (69.1 to 76.9)	38.8 (35 to 42.8)	44.8 (40.6 to 49)
Employed % (95% CI)	72.6 (71.1 to 74.1)	42.2 (34.5 to 50.6)	80.4 (76.2 to 84)	67.7 (64.9 to 70.4)	72 (67.9 to 75.8)	62.5 (58.6 to 66.3)	78.4 (74.7 to 81.6)
Smoking % (95% CI)	18.5 (17.2 to 19.8)	8.8 (5.0 to 14.6)	28.3 (24.1 to 32.9)	17.6 (15.5 to 20)	26.7 (22.9 to 30.7)	7.7 (5.8 to 10.1)	21.5 (18.2 to 25.2)
Recommended physical activity % (95% CI)	65.4 (63.7 to 67.1)	65.2 (55.8 to 73.9)	73 (68 to 77.4)	65 (62 to 68)	63.7 (59.1 to 68)	60.7 (56.3 to 65)	66.2 (61.9 to 70.3)
Body mass index, median (95% range) kg/m^2	26.1(18.0–40.9)	27.4(19.3–41.1)	25.1(18.1–41.0)	26.4(18.0–39.7)	26.4(18.4–40.9)	25.0(18.0–41.7)	25.7(17.2–39.9)
Waist circumference, median (95% range) cm	86.8 (63.0–120.1)	90.0 (61.9–126.8)	85.3 (65.1–124.0)	90.0 (64.0–123.0)	86.4 (62.2–114.7)	82.3 (63.0–119.0)	85.0 (60.0–121.1)
Systolic blood pressure, mean (SD) mm Hg	118.9 (19.1)	116.7 (18.4)	121.92 (19.5)	119.6 (18.7)	120.3 (19.9)	117.5 (18.6)	117.2 (20.1)
Diastolic blood pressure, mean (SD) mm Hg	78.3 (12.6)	75.8 (11.7)	78.6 (13.3)	79.9 (12.1)	80.0 (12.8)	76.9 (12.8)	76.8 (12.2)
Total cholesterol, mean (SD) mmol/L	4.4 (1.1)	4.5 (1.0)	4.2 (1.0)	4.6 (1.0)	4.8 (1.0)	4.0 (1.0)	4.3 (1.1)
HDL cholesterol, mean (SD) mmol/L	1.2 (0.3)	1.2 (0.4)	1.3 (0.4)	1.1 (0.3)	1.1 (0.3)	1.3 (0.3)	1.2 (0.3)
LDL cholesterol mean (SD) mmol/L	3.0 (0.9)	3.1 (0.9)	2.8 (0.9)	3.2 (0.9)	3.3 (0.9)	2.6 (0.9)	2.9 (0.9)
Triglycerides mean (SD) mmol/L	1.3 (1.3)	1.4 (0.9)	1.0 (0.8)	1.5 (1.4)	1.6 (1.3)	0.9 (0.5)	1.2 (1.9)

The values are estimated means (SD), medians (95% range) or proportions (% (CI)) and are based on weighted data. The sample weights included adjustment weights for sex and age. Additional adjustment weights for ethnicity were included in the analyses of the overall group.
Q, income status quintile.

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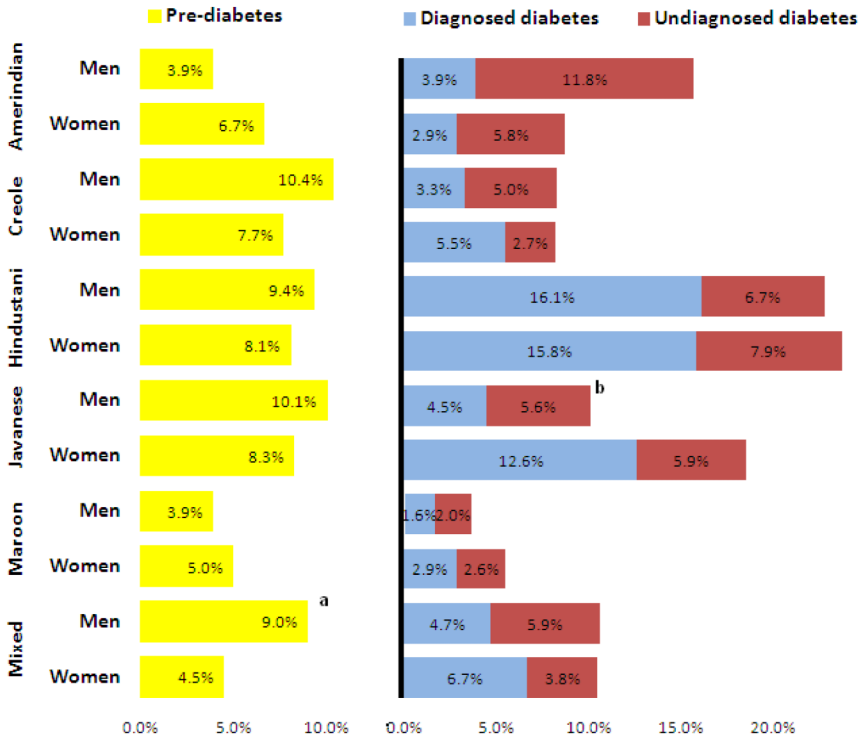

Figure 1 The prevalence of prediabetes, diagnosed and undiagnosed diabetes for males and females from an Amerindian, Creole, Hindustani, Javanese, Maroon and Mixed ethnic background.

a. The difference in the prevalence of pre-diabetes for Mixed was significant between sexes ($p<0.05$).

b. The difference in the prevalence of diagnosed and total diabetes for Javanese was significant between sexes ($p<0.05$).

All differences between sexes for Amerindians, Creoles, Hindustani and Maroons were not significant ($p>0.05$). The difference of pre-diabetes and undiagnosed diabetes between sexes for Javanese was not significant ($p>0.05$). The difference of diagnosed and undiagnosed diabetes between sexes in Mixed was not significant ($p>0.05$).

unemployment compared to employment, we observed a negative association in Amerindian and Creole people and a positive association in Mixed people. For lifestyle factors, smoking had a strong positive association and increased physical activity had a strong negative association in Amerindians. In the other groups, we observed no other significant association with lifestyle factors. Overall and in each ethnic group, anthropometric factors were associated with prediabetes or diabetes. We observed a positive association for prediabetes or diabetes with WC overall and in all ethnicities. For BMI, the association in Amerindians and Maroons was not found significant in contrast to all other groups. The association started at lower BMIs in Creole and Hindustani people compared to Javanese and Mixed people. For metabolic factors overall, we observed that high total cholesterol, low HDL cholesterol, high triglyceride levels and hypertension were associated with an increased risk of prediabetes or diabetes. A positive association with hypertension was also observed in Hindustani, Javanese, and Mixed people. The OR for high total-cholesterol was also significant in Hindustanis and the Javanese. Among the Amerindian, Creole, Hindustani and Mixed people the odds of diabetes or pre-diabetes was higher with low HDL levels. No associations were observed for LDL cholesterol. In all ethnic groups, but Amerindians, we observed a positive association for prediabetes or diabetes and triglycerides.

Ethnic differences, adjusted to risk factors, in (1) pre-diabetes or diabetes and (2) diabetes

Table 3 shows that in the basic model, when adjusted only for age and sex, all ethnic groups had lower risks for prediabetes or diabetes compared to Hindustanis. In this first model, the ORs in the ethnic groups varied from 0.3 (95% CI 0.2 to 0.4) in Maroons to 0.5 (95% CI 0.4 to 0.7) in Javanese compared to Hindustanis. After the addition of demographic factors to the basic model, the OR for Amerindians compared to Hindustanis changed from 0.5 (95% CI 0.3 to 0.7) to 0.6 (95% CI 0.4 to 1.1) and after adjusting for all risk factors to 0.8 (95% CI 0.4 to 1.6). The OR for Creoles compared to Hindustanis was 0.4 in the models 1, 2, 3 and 4. In model 5, where next to the basic model, we additionally adjusted for metabolic factors and in model 6, where we adjusted for all risk factors, the OR for Creoles compared to Hindustanis was 0.6 (95% CI 0.4 to 0.8) and 0.7 (95% CI 0.4 to 1.1), respectively. The difference in

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Table 2 ORs for prediabetes or diabetes by various risk factors

Characteristics	Overall n=3393	Amerindian n=274	Creole n=397	Hindustani n=886	Javanese n=515	Maroon n=809	Mixed n=454
Sex							
Male	1	1	1	1	1	1	1
Female	0.9 (0.8 to 1.1)	1.0 (0.4 to 2.6)	0.8 (0.5 to 1.4)	0.9 (0.7 to 1.2)	1.5 (1.0 to 2.4)	1.4 (0.8 to 2.5)	0.7 (0.4 to 1.1)
Age (years)							
15–34	1	1	1	1	1	1	1
35–44	3.6 (2.8 to 4.6)*	9.4 (2.4 to 36.8) *	4.6 (2.1 to 9.8)*	2.9 (2.0 to 4.1)*	3.2 (1.6 to 6.6)*	5.8 (2.7 to 12.2)*	1.9 (1.0 to 3.5)*
45–54	7.1 (5.6 to 9.0)*	10.9 (2.6 to 45.9)*	4.7 (2.3 to 9.6)*	6.5 (4.6 to 9.2)*	8.7 (4.4 to 17.6)*	8.8 (4.1 to 19.1)*	3.8 (2.0 to 7.1)*
55–64	10.4 (8.0 to 13.6)*	13.6 (2.7 to 67.9)*	5.8 (2.7 to 12.4)*	11.6 (7.5 to 18.1)*	17.2 (8.1 to 36.6)*	9.3 (4.0 to 21.5)*	8.3 (4.3 to 15.8)*
Education							
Low	1	1	1	1	1	1	1
Middle	1.0 (0.8 to 1.2)	1.1 (0.3 to 3.9)	1.5 (0.8 to 3.0)	0.8 (0.6 to 1.2)	0.9 (0.5 to 1.5)	0.7 (0.3 to 2.2)	0.7 (0.4 to 1.2)
High	0.8 (0.6 to 1.0)	6.0 (0.9 to 41.8)	1.5 (0.7 to 2.9)	0.6 (0.4 to 0.9)*	0.6 (0.3 to 1.3)	3.1 (1.4 to 7.0)*	0.6 (0.3 to 1.0)
Income status							
q1-lowest	1	1	1	1	1	1	1
q2	1.0 (0.8 to 1.3)	0.7 (0.3 to 3.3)	1.5 (0.6 to 4.1)	0.6 (0.4 to 0.9)*	0.7 (0.3 to 1.4)	1.5 (0.6 to 3.5)	0.9 (0.4 to 2.1)
q3	0.8 (0.6 to 1.2)	2.7 (0.2 to 45.0)	2.4 (0.8 to 7.0)	0.4 (0.2 to 0.8)*	0.6 (0.3 to 1.5)	1.1 (0.2 to 5.0)	0.4 (0.2 to 1.3)
q4 and q5-highest	0.7 (0.5 to 1.0)*	1.4 (0.2 to 8.9)	3.0 (1.0 to 9.3)*	0.4 (0.2 to 0.7) *	0.7 (0.3 to 1.6)	2.1 (0.6 to 7.3)	0.3 (0.1 to 0.7)*
Residential area							
Urban coastal	1	1	1	1	1	1	1
Rural coastal	1.0 (08 to 1.3)	1.3 (0.5 to 3.8)	1.1 (0.5 to 2.3)	1.0 (0.7 to 1.4)	0.7 (0.4 to 1.3)	1.7 (0.7 to 4.7)	0.8 (0.4 to 1.7)
Rural interior	0.4 (0.2 to 0.5) *	0.2 (0.1 to 0.7) *	NA	NA	NA	0.9 (0.5 to 1.7)	NA
Marital status							
Not married	1	1	1	1	1	1	1
Married	0.8 (0.7 to 1.0)*	1.5 (0.6 to 4.1)	0.8 (0.4 to 1.4)	1.0 (0.7 to 1.3)	0.9 (0.5 to 1.5)	0.8 (0.5 to 1.4)	1.0 (0.6 to 1.7)
Employment							
Employed	1	1	1	1	1	1	1
Not employed	1.1 (0.9 to 1.3)	0.4 (0.1 to 1.0)*	0.2 (0.1 to 0.6)*	1.3 (0.9 to 1.8)	1.1 (0.6 to 1.9)	1 (0.6 to 1.6)	2.4 (1.3 to 4.3) *
Smoking status							
Not smoking	1	1	1	1	1	1	1
Smoking	1.2 (0.9 to 1.5)	6.1 (1.5 to 24.8)*	0.8 (0.4 to 1.5)	1.2 (0.8 to 1.7)	1.2 (0.7 to 2.1)	1.8 (0.7 to 5.0)	1.0 (0.6 to 1.7)
Physical activity							
MET<600	1	1	1	1	1	1	1
MET≥600	0.9 (0.7 to 1.0)	0.2 (0.1 to 0.7)*	1.3 (0.7 to 2.6)	0.7 (0.5 to 0.9)*	0.9 (0.5 to 1.5)	1.1 (0.6 to 2.2)	1.0 (0.6 to 1.6)
Body mass index							
<25	1	1	1	1	1	1	1
25–27.5	1.7 (1.3 to 2.3) *	3.3 (0.7 to 16.0)	5.4 (2.2 to 13.4) *	1.6 (1.1 to 2.5) *	0.8 (0.4 to 1.6)	1.4 (0.6 to 3.3)	0.8 (0.4 to 2.0)
27.5–30	2.1 (1.6 to 2.8) *	3.3 (0.8 to 13.5)	5.6 (2.2 to 13.8) *	1.7 (1.1 to 2.6) *	2.0 (1.0 to 3.8)*	0.7 (0.2 to 1.9)	2.2 (1.1 to 4.1)*
30+	3.0 (2.3 to 3.7) *	3.5 (0.9 to 13.0)	7.6 (3.4 to 16.8) *	3.9 (2.1 to 4.2) *	2.7 (1.5 to 4.8) *	1.6 (0.8 to 3.3)	2.9 (1.6 to 5.0) *
Waist circumference (cm)							
≤102	1	1	1	1	1	1	1
>102	2.5 (2.0 to 3.0) *	3.8 (1.3 to 11.7)*	3.8 (2.0 to 7.3) *	2.0 (1.9 to 4.3) *	1.4 (1.4 to 4.0)*	2.7 (1.3 to 5.8) *	2.6 (1.3 to 4.4) *
Blood pressure							
Normal	1	1	1	1	1	1	1

Continued

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Table 2 Continued

Characteristics	Overall n=3393	Amerindian n=274	Creole n=397	Hindustani n=886	Javanese n=515	Maroon n=809	Mixed n=454
High	2.2 (1.8 to 2.6) *	1.2 (0.4 to 3.2)	1.1 (0.6 to 2.0)	2.7 (2.0 to 3.7) *	2.6 (1.6 to 4.2) *	1.2 (0.6 to 2.3)	1.9 (1.1 to 3.3)*
Total cholesterol							
<6.2 mmol/L	1	1	1	1	1	1	1
≥6.2 mmol/L	1.9 (1.4 to 2.6) *	1.5 (0.2 to 8.6)	0.3 (0.1 to 1.5)	2.0 (1.2 to 3.3)*	3.6 (1.8 to 7.2) *	1.8 (0.8 to 4.1)	1.7 (0.8 to 4.1)
HDL cholesterol							
≥1.3 mmol/L	1	1	1	1	1	1	1
<1.3 mmol/L	2.0 (1.6 to 2.5) *	6.7 (1.9 to 24.4)*	2.0 (1.1 to 3.5)*	1.9 (1.3 to 2.7)*	1.2 (0.7 to 2.2)	1.3 (0.8 to 2.3)	2.1 (1.2 to 3.7)*
LDL cholesterol							
<3 mmol/L	1	1	1	1	1	1	1
≥3 mmol/L	1.1 (0.9 to 1.4)	1.3 (0.5 to 3.2)	1.1 (0.6 to 2.0)	0.8 (0.6 to 1.1)	0.8 (0.5 to 1.4)	1.2 (0.7 to 2.4)	1.2 (0.7 to 2.0)
Triglycerides							
<1.7 mmol/L	1	1	1	1	1	1	1
≥1.7 mmol/L	2.7 (2.1 to 3.4) *	0.7 (0.2 to 1.9)	2.7 (1.0 to 7.1)*	2.3 (1.6 to 3.2)*	2.7 (1.7 to 4.5)*	10.2 (4.0 to 25.7)*	5.6 (2.8 to 11.0)*

ORs adjusted to sex and age were calculated in weighted data (*p<0.05).
The sample weights included adjustment weights for sex and age.
Additional adjustment weights for ethnicity were included in the analyses of the overall group.
BMI, body mass index; MET, metabolic equivalent of task; NA, not applicable; q, income status quintile.

OR between Javanese, Maroons, Mixed and Hindustanis remained similar after adding demographic, lifestyle, anthropometric and metabolic factors to age and sex. In model 6, however, the OR for all ethnicities moved closer to 1.

Table 4 shows the same trend for diabetes, but with stronger associations in the basic model. Compared to table 3, the differences in association between the basic model and the model including demographic factors and the model with all risk factors were larger in table 4. For Amerindians, the OR compared to Hindustanis for diabetes was 1.0 (95% CI 0.5 to 2.3) when adjusted for all the risk factors.

DISCUSSION

The results of this first nationwide study indicate that the overall prevalence of diabetes was elevated (13%), in particular among Hindustanis (23%). From the participants with diabetes, 39.6% was not diagnosed previously. This percentage differed among the ethnicities and was highest for Amerindian men and Hindustani women. The distribution and association of biological, demographic, lifestyle, anthropometric and metabolic risk factors varied between ethnic groups. Compared to Hindustanis, all ethnic groups had a lower OR for prediabetes or diabetes. This difference decreased, in particular between Amerindians and Hindustanis, as we adjusted for all risk factors.

Prevalence

Previous studies have estimated a diabetes prevalence of 9% in the Caribbean and 10% in Suriname.[1 18 32] These studies were based on smaller samples sizes and limited to the coastal areas with older study populations.[1 18 32] In the current study, with inclusion of the rural interior and the younger age groups, we found a higher prevalence of diabetes. Moreover, our prevalence of undiagnosed diabetes was even five times higher than the previous estimate made by the International Diabetes Federation in 2013.

Compared to the diabetes prevalences published (9.0–21.1%) in studies in Indians and other descendants from India,[15 33–36] the Hindustanis in our study had a higher diabetes prevalence. Previously reported differences for diabetes prevalence between ethnic groups are not consistent in the UK, the US and the Netherlands.[11 14 15 36–38] However, on the basis of previous studies in the Netherlands,[14 15] we expected a higher prevalence in Hindustanis compared to other ethnicities as observed in our study.

The difference between sexes for the overall population was not evident for diabetes, while the prevalence of prediabetes was higher in men. These findings are in line with previous studies.[24] Except for Javanese, we observed no difference for diabetes prevalence between sexes within ethnic groups. The higher prevalence that we observed in Javanese women was in line with studies

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Table 3 Models of association of prediabetes or diabetes among ethnic subgroups

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Model 6 OR (95% CI)
Hindustani	1	1	1	1	1	1
Amerindian	0.5 (0.3 to 0.7)*	0.6 (0.4 to 1.1)	0.5 (0.3 to 0.8)*	0.5 (0.3 to 0.7)*	0.5 (0.3 to 0.7)*	0.8 (0.4 to 1.6)
Creole	0.4 (0.3 to 0.5)*	0.4 (0.3 to 0.7)*	0.4 (0.3 to 0.6)*	0.4 (0.3 to 0.6)*	0.6 (0.4 to 0.8)*	0.7 (0.4 to 1.1)
Javanese	0.5 (0.4 to 0.7)*	0.5 (0.4 to 0.8)*	0.5 (0.4 to 0.7)*	0.6 (0.5 to 0.8)*	0.5 (0.4 to 0.7)*	0.6 (0.4 to 0.9)*
Maroon	0.3 (0.2 to 0.4)*	0.3 (0.2 to 0.5)*	0.3 (0.2 to 0.4)*	0.3 (0.2 to 0.4)*	0.4 (0.3 to 0.5)*	0.5 (0.3 to 1.0)
Mixed	0.5 (0.4 to 0.6)*	0.5 (0.3 to 0.7)*	0.6 (0.4 to 0.7)*	0.5 (0.4 to 0.7)*	0.5 (0.4 to 0.7)*	0.5 (0.3 to 0.8)*

*(p<0.05).
Model 1 is the basic multivariate model adjusted for sex and age.
Model 2 is adjusted for variables in model 1 plus demographic factors like living area, marital status, education, income and working status.
Model 3 is adjusted for variables in model 1 plus lifestyle factors like smoking and physical activity.
Model 4 is adjusted for variables in model 1 plus anthropometric measures like BMI and WC.
Model 5 is adjusted for variables in model 1 plus metabolic measures like blood pressure, total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides.
Model 6 is adjusted for variables in model 1, 2, 3, 4 and 5.
BMI, body mass index; HDL, high-density lipoprotein; LDL low-density lipoprotein; WC, waist circumference.

in Indonesians.[39] This could be related to the low physical activity as numerous studies are showing that increased physical activity reduces the risk of diabetes.[39 40] Published results from the Suriname Health Study show the lowest percentage of required physical activity for Javanese women.[26] The results on age in our study are in line with the literature for all ethnic groups.[25] The observed prevalences of diabetes in our study are high and actions for the early detection, prevention and control of diabetes are required. The differences observed between ethnic groups suggest the development of ethnic-specific strategies. These interventions should take account of different risk factors.

Ethnic differences in risk factors

The ORs observed for biological risk factors in this study are in line with previous studies.[13 24 25 41] The associations of demographic risk factors with prediabetes or diabetes observed in the total and ethnic subgroups have been described earlier.[42–44] However, not all findings were consistent. The positive association with prediabetes or diabetes we observed of 'high education' in Maroons and of 'high income' in Creoles contrasted the negative association with prediabetes or diabetes, of 'high education' and 'high income' in Hindustanis. The association of 'not employed' with prediabetes or diabetes was positive in Mixed and negative in Amerindians and Creoles. These inverse associations cannot be explained with the available data and need to be explored in more detail. In anthropometric risk factors, the positive association of WC with prediabetes or diabetes demonstrated for all ethnic groups in our study is in line with the literature.[45–47] Previous publications state that non-white populations develop diabetes at a higher rate at BMIs below 25 Kg/m^2, the WHO cut-off point for overweight.[29 48] Our results demonstrated an association of BMI with pre-diabetes or diabetes, initiated from lower values in Creole and Hindustani people compared to Javanese and Mixed people. The earlier association in Hindustanis is in agreement with the lower cut-off point published for Asians.[29] Higher cut-off points are published for ethnicities of African

Table 4 Models of association of diabetes among ethnic subgroups

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Model 6 OR (95% CI)
Hindustani	1	1	1	1	1	1
Amerindian	0.5 (0.3 to 0.8)*	0.9 (0.5 to 1.7)	0.5 (0.3 to 0.9)*	0.4 (0.3 to 0.7)*	0.5 (0.3 to 0.8)*	1.0 (0.5 to 2.3)
Creole	0.3 (0.2 to 0.4)*	0.5 (0.3 to 0.8)*	0.3 (0.2 to 0.4)*	0.3 (0.2 to 0.4)*	0.3 (0.2 to 0.5)*	0.6 (0.4 to 1.1)
Javanese	0.4 (0.3 to 0.6)*	0.6 (0.4 to 1.0)*	0.4 (0.3 to 0.6)*	0.5 (0.4 to 0.7)*	0.4 (0.3 to 0.6)*	0.6 (0.4 to 1.0)
Maroon	0.2 (0.1 to 0.3)*	0.3 (0.2 to 0.6)*	0.2 (0.1 to 0.3)*	0.2 (0.1 to 0.3)*	0.3 (0.2 to 0.4)*	0.5 (0.2 to 1.0)*
Mixed	0.4 (0.3 to 0.6)*	0.4 (0.2 to 0.7)*	0.5 (0.3 to 0.7)*	0.4 (0.3 to 0.6)*	0.5 (0.3 to 0.7)*	0.4 (0.2 to 0.8)*

*(p<0.05).
Model 1 is the basic multivariate model adjusted for sex and age.
Model 2 is adjusted for variables in model 1 plus demographic factors like living area, marital status, education, income and working status.
Model 3 is adjusted for variables in model 1 plus lifestyle factors like smoking and physical activity.
Model 4 is adjusted for variables in model 1 plus anthropometric measures like BMI and WC.
Model 5 is adjusted for variables in model 1 plus metabolic measures like blood pressure, total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides.
Model 6 is adjusted for variables in model 1, 2, 3, 4 and 5.
BMI, body mass index; HDL, high-density lipoprotein; LDL low-density lipoprotein; WC, waist circumference.

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descent,[49–51] which contradicts the association of BMI observed in Creoles. The associations at higher BMI values for Javanese and the absence of an association in Amerindians and Maroons, however, are not explained by differences in cut-off values between ethnicities. To explore the ethnic differences concerning the association of BMI with prediabetes or diabetes in more depth, further research on variations in body composition and cut-off values is needed. The associations of the metabolic risk factors (increased blood pressure, total cholesterol and triglycerides and low HDL cholesterol) with prediabetes or diabetes in our study are in line with previous findings.[7 8 52] In our study, the lipid profiles from the ethnic groups of African descent seemed less associated with diabetes in comparison to other ethnicities. This coincides with published studies.[38] Previous studies implicate that physical activity is associated with increased HDL cholesterol.[53–55] For the Amerindians, we found a negative association of HDL cholesterol, a negative association of physical activity and no association of triglycerides with prediabetes and diabetes. Physical activity might have influenced the association of HDL cholesterol with prediabetes or diabetes in Amerindians.

Research implicates that adults with both diabetes and hypertension have the worst of many complications.[56–58] The strongest association with hypertension was found in Hindustanis and Javanese, placing these groups at higher risk. More detailed research is required to develop or adapt risk scores for screening in ethnic groups.

Ethnicity as risk factor

Our study results suggest that biological, demographic, lifestyle, anthropometric and metabolic risk factors influence the association of ethnic groups with prediabetes and diabetes combined and more evidently with diabetes. Previous studies on Amerindians have shown a vast increase in the incidence and prevalence of diabetes when living with risk factors in urbanized settings.[59 60] Many studies also show high prevalences for Indians and descendants from India.[15 33 34 36] The difference between the OR of mainly Amerindians and Hindustanis observed in this study decreases with the adjustment of all risk factors. This is in line with higher prevalences found in these groups in urban settings. Studies comparing the ethnic groups similar to our study are scarce as most ethnic comparisons are made with Caucasians.[12] The high OR of Hindustanis with diabetes, compared to the other ethnic groups, remains after adjusting for all different risk factors. The faster conversion from prediabetes to diabetes, previously observed in Hindustanis,[14] might contribute to the higher prevalence we observed for Hindustanis in our study. For a complete analysis, other risk factors, for example, diet, should also be considered.[61] Genetic factors[33 62] might play a role but heritable epigenetic changes, epistasis and gene–environment interactions also need further research.[63] For the development and application of ethnic-specific guidelines for the prevention and treatment of diabetes preferably, follow-up studies are needed.

Strengths and limitations

The strengths of this cross-sectional study were the design with a stratified multistage cluster, adequate to represent the ethnic and geographic diversity of the Surinamese population by sex in five different age groups.[19] The design included standardized data collection tools and used measures like the Kish[20] method to minimize interviewer and selection bias. The use of trained interviewers, the inclusion of control questions in the questionnaire, and the intense revision on consistency and completeness including random checks on responses of participants improved the validity of our self-reported data.[19] In addition, in the analysis, sample weights were applied to correct for selection and response bias. All blood samples were analyzed in a certified laboratory. Further, the percentage of missing data in general was relatively small (<2%), except for of the information on income status (41.6%).

Still, some limitations should be considered. First, from all participants, 59% met the criteria of an 8 hours overnight fast. Although sample weights were applied, this high non-response for blood samples might have still resulted in self-selection bias, inflating the outcomes on prevalence. Second, although the wide range of variables evaluated in this study allowed control for confounders, residual confounding might still have occurred, as with any observational study. For example, information on nutrition was not considered. Third, we used the WHO criteria on fasting plasma glucose to define diabetes and prediabetes in our study. The combined use of the fasting plasma glucose and the oral glucose tolerance test could have resulted in a slightly higher prevalence.[64]

CONCLUSION

The prevalence of diabetes in Suriname has reached epidemic levels. The prevalence in Hindustanis is considerably higher compared to the prevalence in other ethnic groups. The observed variations in risk factors among ethnic groups might in part explain the ethnic differences in the prevalence of diabetes, but follow-up studies are needed to explore this in more depth. The high prevalence of diabetes observed in our results may have considerable health and economic repercussions. To prevent a further rapid increase in the prevalence of diabetes in Suriname, it is important to practise risk assessment for early detection and control of the disease. More research with preferably longitudinal studies is needed to assess ethnic-specific risk tools to screen for diabetes.

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