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Prediabetes in a French overseas territory: Clinical Characteristics, Risk Factors, and Implications for type 2 diabetes prevention

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ABSTRACT

Background: People with prediabetes are at high risk of developing type 2 diabetes (T2D). This study evaluates clinical, sociodemographic characteristics, and Finnish Diabetes Risk Score (FINDRISC) of individuals with prediabetes recruited in primary care by their general practitioner (GP) for PREDIABRUN study.
Methods: PREDIABRUN, a prospective cohort study in primary care on Reunion Island, aimed to identify risk factors for developing T2D in 500 adults with prediabetes (18–70 years) between July 2019 and December 2022. Sociodemographic, anthropometric, health, and lifestyle data were collected. Participants were categorized as having known prediabetes if their GP was aware of glucose abnormalities before the study, otherwise as newly diagnosed.
Results: A total of 469 subjects were included, with a median age of 55 years; 58.4 % were women. Employment was more common among men (53.3 %) than women (36.1 %). Precariousness affected 35.4 % overall, with higher rates in women (41.6 %) than men (26.7 %, $p < 0.001$). The major associated health issues were obesity (40.1 %), musculoskeletal disorders (50.5 %), hypertension (46.3 %) and cardiovascular diseases (11.5 %). The median FINDRISC score was 16 [IQR: 12–19], higher in women (17 [14–20]) than men (15 [11–17], $p < 0.001$). For more than half the population (55.0 %), prediabetes status was already known. However, lifestyle habits were similar for those with newly diagnosed prediabetes and those with prediabetes already known.
Conclusion: Screened population in primary care on Reunion Island is relatively young, with a high FINDRISC score and numerous medical conditions. Tailored intervention to improve dietary habits and increase physical activity could help prevent diabetes in this high-risk group.

1. Introduction

Prediabetes is a pivotal stage, delineating individuals whose blood glucose levels exceed the normal range but don't qualify for the diagnosis of type 2 diabetes (T2D). In absence of intervention, up to 70 % of those individuals with prediabetes will progress to T2D during their lifetime (Gerstein et al., 2007 Dec 1; Rooney et al., 2023 May 17). Prediabetes also increases the risk of cardiovascular death and overall mortality (Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia [Internet]. [cited, 2024; Nathan et al., 2007). Recognizing and actively addressing this critical juncture is essential for the proactive prevention of T2D and to decrease morbidity and mortality linked to this state. According to the World Health association (WHO), Prediabetes is diagnosed when either impaired fasting blood glucose (plasma glucose levels range from 1.10-1.25 g/l (6.1–6.9 mmol/l)) and/or and glucose intolerance (2-hour post-load glucose level between 1.40–1.99 g/l (7.8–11.0 mmol/l) during an oral glucose tolerance test (OGTT)) are present (Gerstein et al., 2007 Dec 1;

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Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia [Internet]. [cited, 2024; Nathan et al., 2007).

Interventions for prediabetes state primarily consist in counseling and motivational support, empowering individuals with prediabetes to embrace healthier lifestyle. This approach has demonstrated an unparalleled effectiveness, even better than pharmaceutical treatment used for diabetes treatment, in curbing the evolution toward T2D (Howells et al., 2016 Dec 21). The long term decrease on cardiovascular complications and mortality has been also demonstrated but in fewer study (Yeung et al., 2021 Aug; Cai et al., 2020 Jul) and after more than 10 years of follow-up.

Active prevention of T2D through diagnosis and care of prediabetes are within the many missions of Primary care (Kandula et al., 2018 Jan; Harcke et al., 2023 Dec 13). However, primary care professionals encounter challenges in screening and managing prediabetes, stemming from diverse definition of prediabetes worldwide, the limited recognition of prediabetes as a distinct disease, challenges in prescribing OGTT, the absence of dedicated pharmaceutical options and constraints related to time and limited resources (Montee et al., 2022 Apr). Additionally, individuals regard prediabetes state with skepticism: 'it is not diabetes yet' hindering healthcare providers in effectively guiding subjects with prediabetes towards lifestyle improvement (Skoglund et al., 2022 Mar 21). These different factors partially account for the observed difficulties to efficiently prevent the growing pandemic of diabetes worldwide. Further insight are required for enhancing our understanding of the screening and management of prediabetes in primary care, particularly the factors influencing its progression toward diabetes.

Prevention of diabetes and its complications is a top health priority in Reunion Island. The impact of diabetes on the health of Reunionese population is significant: the prevalence of treated diabetes at 10 % is the highest in all France (Ricquebourg et al., 2023), and gestational diabetes is found for nearly 20 % of pregnancies (Le diabète et les personnes diabétiques à La Réunion, 2022). Despite the active screening and prevention programs in place, the burden of diabetes on the island continues to grow, with 4,300 new cases annually, 95 % of which being T2D (Mandereau-Bruno et al., 2017). While data on prediabetes in Reunion Island is limited, risk factors like family history of diabetes, low HDL-C levels, hypertension, metabolic syndrome, gestational diabetes, precariousness and at risk-ethnic origin are overrepresented (Montee et al., 2022 Apr; Anthony et al., 2021 Jul). However, the significance of diet and physical activity, and the interplay between the various risk factors need further investigation (Richter et al., 2018; Heianza et al., 2011 Jul 9). Longitudinal studies have revealed that many with prediabetes revert to normoglycemia, often accompanying shifts in certain cardiovascular risk factors (Tabák et al., 2012 Jun 16; Perreault et al., 2012 Jun 16; Vistisen et al., 2019 Aug; Narayan et al., 2024 Mar 1).

In this study, the primary objective was to assess the clinical, sociodemographic characteristics, and the Finnish Diabetes Risk Score (FINDRISC) of individuals diagnosed with prediabetes by their general practitioner in Reunion Island. The secondary objective was to estimate the impact on prediabetes diagnosis on dietary habits, physical activity and health data.

2. Methods

1. Study design and population

The PREDIABRUN prospective cohort study (2018-A03106-49) is a 5-years follow-up study conducted in primary care in Reunion Island (Anthony et al., 2022 Nov 21; Bun et al., 2023). The aim is to identify the risk factors for developing T2D in people with prediabetes aged between 18 to 70 years on Reunion Island. The French Research Ethics Committee (CPP 2019–03) approved the data collection procedures and utilization of information in the PREDIABRUN study, and participants provided informed consent. The comprehensive methodology of the overall PREDIABRUN study has been detailed previously (Richter et al., 2018).

2. Patient and public involvement.

The recruitment process for the PREDIABRUN study involved General practitioners (GP) who actively sought potential participants among their patients. Interested and eligible subjects were then given information about the study. After they agreed to participate and provided written consent, participants' medical history was obtained, and basic biological examinations were carried out with the attending GP. All socio-demographic data, lifestyle habits and physical activity were obtained through telephone interview sessions by trained interviewers using a set of standardised and verified questionnaires and entered in an electronic case report form via Ennov Clinical (Clinsight).

3. Data processing.

The present study is based on data obtained at the time of inclusion in the PREDIABRUN cohort study. A total of 500 patients were included from 18 July 2019 to 30 December 2022. Among them, 31 patients were excluded due to discontinuation of study participation (refusal of telephone interview in majority). Sociodemographic and clinical data, food habits, and physical activity of the participants at the time of their inclusion in the study were used.

2.1. Sociodemographic and clinical data

The Universal Health-Care Coverage (CMU) or Complementary Universal Health-Care Coverage (CMU-C) is a health insurance plan for those who are not otherwise covered through business or employment and who have a low income (Complementary health solidarity (ex-CMU-C) [Internet]. [cited, 2024). A new variable, precariousness, has been created. Patients were classified as being precarious if they benefit from CMU-C or CMU. Individuals have been classified into three categories considering their body mass index (BMI): less than 25 kg/m^2 considered normal or healthy weight, between 25 and 29 kg/m^2 overweight and 30 kg/m^2 or more considered obese (Obesity [Internet]. [cited, 2024). Male and female waist circumferences of ≥ 94 cm and ≥ 80 cm, respectively, were considered elevated (Autorité, 2024). First-degree family diabetes involves the father, mother, brothers and sisters. The item cardiovascular diseases concerned a history of stroke, coronary insufficiency, obliterating arteriopathy of the lower limbs, heart failure, carotid stenosis, coronary revascularization. A participant was considered to have prediabetes already known if the antecedent of glucose abnormality was known by the GP prior to the glucose measurement conducting to the patients' inclusion in the study, and otherwise was considered to have prediabetes newly diagnosed. A depression score was generated using the Center for Epidemiologic Studies-Depression (CES-D) scale, which consists of 20 questions. The points obtained for each question, ranging from 0 to 3, were summed to calculate the overall score. A score of 0 to 9 indicated no depression, 10 to 15 suggested mild depression, 16 to 24 indicated moderate depression, and a score exceeding 25 signified severe depression.

2.2. Findrisc

The FINDRISC is a tool for detecting people at risk of developing diabetes largely used worldwide (FindRisk Péi : repérer le diabète au plus tôt [Internet]., 2023). The total score obtained is between 0 and 26, being the sum of the scores obtained for the eight questions (age (years), BMI (kg/m2), physical activity (at least 30 min a day), daily consumption of vegetables and fruit, family history of diabetes, hyperglycemia detected at any time, blood pressure and waist circumference measurement (cm)). The FINDRISC is classified into four categories: low (<12), moderate (Ricquebourg et al., 2023; Le diabète et les personnes diabétiques à La Réunion, 2022; Mandereau-Bruno et al., 2017), high

(Anthony et al., 2021 Jul; Richter et al., 2018; Heianza et al., 2011 Jul 9; Tabák et al., 2012 Jun 16; Perreault et al., 2012 Jun 16; Vistisen et al., 2019 Aug) or very high (>20). The score was only calculated for patients who answered all the questions with no missing data.

2.3. Statistical analysis

Categorical data are reported as counts and percentages. Continuous data are reported as mean ± standard deviation (SD) for normally distributed data and as median (interquartile range [IQR]) for non-normally distributed data. Comparisons used the Chi-squared test or Fisher's exact test for categorical variables and Student's *t*-test or the Mann–Whitney–Wilcoxon test, as appropriate, for continuous variables. Logistic regression analysis was performed to assess the association between prediabetes status (already known vs. newly diagnosed prediabetes) and individual lifestyle habits as well as medical characteristics. All analyses were adjusted for age and sex to account for potential confounding effects. Odds ratios (ORs) with 95 % confidence intervals (CIs) were calculated to quantify these associations. A 2-tailed p-value < 0.05 was considered statistically significant. All data were analysed using R software, version 4.2.2 (R Project for Statistical Computing, Vienna, Austria).

3. Results

1. Sociodemographic characteristics of participants in the PREDIABRUN study (Table 1, Appendix).

The final number of subjects retained for this study was 469. Their median age was 55 [IQR: 48.0–62.0] years with 83.4 % of patients between 45 and 70 years of age and 16.6 % < 45 years. Women represent 58.4 % of the population, 62.7 % of the participants were in a relationship and a large majority of participants (88.5 %) were native Reunionese. There was no statistical difference in education level between men and women, but their professional situation differed (p < 0.001), with 53.3 % of men working (full or part-time) compared to 36.1 % of women. Similarly, precariousness concerned more likely women than men, with 35.4 % of the population with precariousness raising to 41.6 % in women compared to 26.7 % in men (p < 0.001), and 13.1 % of women having already refused care for financial reasons compared to 6.7 % of men (p = 0.024). Of note, 52 (16.1 %) patients were active smokers, and 127 (39.3 %) were former smokers; smoking being more frequent in men (p < 0.001) [Table 1]. Those under 45 had a greater proportion of post-secondary or higher education (66.7 %) compared to those aged 45 and older (31.2 %), who predominantly had a primary education (49.9 %) (p < 0.001). Smoking was significantly higher among younger participants (32 %) than among older participants (14 %). There were no difference regarding age for professional activity and precariousness [Appendix 1].

2. Medical characteristics of participants in the PREDIABRUN study (Table 2, Appendix 1).

The diagnosis of prediabetes was established through oral glucose

Table 1
Sociodemographic characteristics of adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469): overall and gender-specific analysis.

	Overall, N = 469	Men, N = 195	Women, N = 274	p-value
Age (years)				
Median [IQR]	55.0 [48.0–62.0]	56.0 [50.0–63.0]	55.0 [47.0–62.0]	0.3
<45	78 (16.6)	31 (15.9)	47 (17.2)	0.9
[45–60]	243 (51.8)	100 (51.9)	143 (52.2)	
>60	148 (31.6)	64 (32.8)	84 (30.7)	
Birthplace – Reunion Island	415 (88.5)	165 (84.6)	250 (91.2)	0.027
Marital status				0.023
Living with a partner	294 (62.7)	134 (68.7)	160 (58.4)	
Living alone	175 (37.3)	61 (31.3)	114 (41.6)	
Education level				0.6
Primary education	205 (43.7)	90 (46.2)	115 (42.0)	
Secondary education	90 (19.2)	34 (17.4)	56.0 (20.4)	
Post-secondary or higher education	174 (37.1)	71 (36.4)	103 (37.6)	
Professional activity				<0.001
Employee	203 (43.3)	104 (53.3)	99 (36.1)	
Unemployed	172 (36.7)	44 (22.6)	128 (46.7)	
Retired	94 (20.1)	47 (24.1)	47 (17.2)	
Precariousness*	166 (35.4)	52 (26.7)	114 (41.6)	<0.001
Renunciation of care for financial reasons	49 (10.5)	13 (6.7)	36 (13.1)	0.024
Smoking status				<0.001
Current smokers	52 (16.1)	26 (18.9)	26 (14.4)	
Former smokers	127 (39.3)	70 (48.9)	57 (31.7)	
Non smokers	144 (44.6)	47 (32.9)	97 (53.9)	

* Precariousness is defined as benefiting from Complementary Universal Health-Care Coverage or Universal Health-Care Coverage. Categorical variables are expressed as n (percentages) and quantitative variables as means ± standard deviation or Median [IQR]. P-values were calculated using Student's *t*-test or Wilcoxon rank-sum tests for continuous variables (depending on data distribution) and Chi-square test or Fisher's exact test for categorical variables.

Table 2
Medical characteristic of adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469): overall and gender-specific analysis.

	Overall, N = 469	Men, N = 195	Women, N = 274	p-value
Elevated waist circumference*	305 (84.3)	109 (73.2)	196 (92.0)	<0.001
Missing	107	46	61	
Body Mass Index (kg/m^2)				0.052
<25	94 (20.3)	44 (23.0)	50 (18.3)	
[25–30[	184 (39.7)	83 (43.5)	101 (37.0)	
≥30	186 (40.1)	64 (33.5)	122 (44.7)	
Missing	5	4	1	
Mean Body Mass Index (kg/m^2)	29.4 ± 6.0	28.6 ± 5.5	29.9 ± 6.2	0.018
Cardiovascular diseases**	54 (11.5)	31 (15.9)	23 (8.4)	0.012
Dyslipidaemia	183 (39.0)	79 (40.5)	104 (38.0)	0.6
Hypertension	217 (46.3)	87 (44.6)	130 (47.4)	0.5
Known prediabetes	258 (55.01)	100 (51.3)	158 (57.7)	0.2
Musculoskeletal impairment	237 (50.5)	99 (50.8)	138 (50.4)	>0.9
Physical restrictions	119 (25.4)	41 (21.0)	78 (28.5)	0.068
General health (scale 1–10)	7.0 ± 1.8	7.1 ± 1.7	7.0 ± 1.9	0.5
Health compared to peers (scale 1–10)	7.1 ± 2.1	7.3 ± 1.9	7.0 ± 2.1	0.13
Depression				0.003
None or Light	336 (71.6)	154 (78.9)	182 (66.4)	
Moderate or Severe	133 (28.4)	41 (21.1)	92 (33.6)	
1st degree familial diabetes***	330 (70.4)	119 (61.0)	211 (77.0)	<0.001

* Elevated waist circumference is defined as ≥ 94 cm for men; ≥80 cm for women.

** Cardiovascular diseases include stroke, coronary insufficiency, obliterating arteriopathy of the lower limbs, heart failure, carotid stenosis, coronary revascularization

*** 1st degree familial diabetes involves the father, mother, brothers, sisters. Categorical variables are expressed as n (percentages) and quantitative variables as means ± standard deviation or Median [IQR]. P-values were calculated using Student's *t*-test or Wilcoxon rank-sum tests for continuous variables (depending on data distribution) and Chi-square test or Fisher's exact test for categorical variables.

tolerance test (OGTT) for 17 (3.6 %) patients, while 452 (96.4 %) patients were diagnosed solely based on fasting glycemia. All subjects included had at least one risk factor for diabetes: dyslipidemia, hypertension, smoking (current or former smoker), or history of diabetes in their first-degree relatives. Obesity was diagnosed in 40.1 % of the participant, more frequently in women (44.7 %) compared to men (33.5 %) and in participants under the age of 45 years compared to those over 45 years (66.7 % vs 34.7 % ($p < 0.001$)). Similarly, an elevated waist circumference was found in 92.0 % of women versus 73.2 % of men; ($p < 0.001$). Respectively 23 % of men and 18.3 % of women presented with a normal body weight. The most frequent medical histories were known prediabetes (55.0 %), musculoskeletal impairment (50.5 %) with half leading to physical restrictions, hypertension (46.3 %), and dyslipidemia (39.0 %). As expected, high blood pressure and dyslipidemia were significantly more prevalent in participants aged 45 or over than in younger participants (respectively, 50.1 %, versus 26.9 % and 41.9 % vs. 24.4 %; $p < 0.001$). On a scale of 10, participants considered their general health at 7 ± 1.8 and 7.1 ± 2.1 for their overall health compared to people of the same age. Younger participants below 45 years had a worst perception of their overall health and health compared with people of the same age, compared to older participants with score respectively 6.6 ± 1.9 vs 7.1 ± 1.8 ($p = 0.041$), and 6.4 ± 2.3 vs 7.2 ± 1.9 ($p = 0.002$). Over 70 % of patients had a family history of first-degree familial diabetes: 84.6 % of participants under 45 and 67.5 % of those over 45 ($p = 0.003$). In terms of mental health, 71.6 % of patients had no sign or mild depression, while 28.4 % had a sign of moderate or severe depression, with a significantly higher proportion of women concerned ($p = 0.003$) [Table 2 and Appendix 1]. As a result of these characteristics, the median FINDRISC score was high: 16 [IQR: 12–19] with 62.2 % having a score of 15 or more (Fig. 1).

3. Role of a previous history of prediabetes known by the GP on lifestyle habits (Tables 3 and 4).

For more than half of the population (55.0 %), the diagnosis of prediabetes was made 1–10 years before the inclusion in the study. Medical characteristics were similar between the population with prediabetes already known and the population with prediabetes newly diagnosed except for age. The population of newly diagnosed subjects with prediabetes was slightly younger than the population with already known diabetes (respectively, 53 [46.5, 61] vs 56 [50, 64] years, $p = 0.001$). When comparing subjects with already known prediabetes to

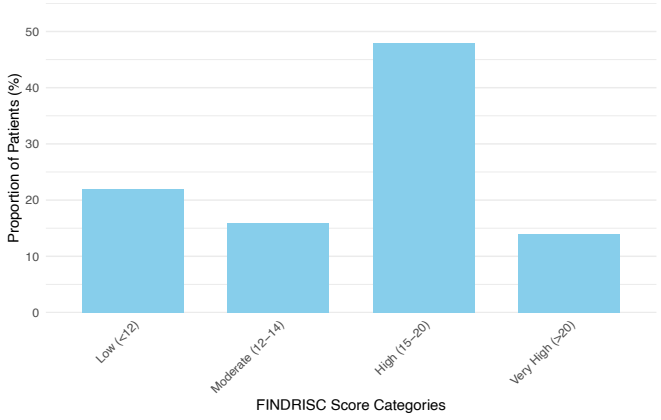

Fig. 1. Distribution by Finnish Diabetes Risk Score (FINDRISC) categories of adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469). *Bar graph showing the proportion of PREDIABRUN participants across Finnish Diabetes Risk Score (FINDRISC) categories. FINDRISC estimates the 10-year type 2 diabetes risk based on various health factors. X-axis: FINDRISC categories (Low < 12, Moderate 12–14, High 15–20, Very High > 20); Y-axis: Proportion of Patients (%).*

Table 3
Comparison of sociodemographic and medical characteristics and lifestyle habits by prediabetes diagnosis status (already known vs. newly diagnosed) among adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469).

	Already known, N = 258	Newly diagnosed, N = 211	p-value
Sex			0.2
Men	100 (38.8)	95 (45.0)	
Women	158 (61.2)	116 (55.0)	
Age (years)			
Median [IQR]	56 [50, 64]	53 [46.5, 61]	0.001
<45	32.0 (12.4)	46.0 (21.8)	0.010
[45–60]	134.0 (51.9)	109.0 (51.7)	
>60	92.0 (35.7)	56.0 (26.5)	
Perceived balance of nutrition (scale 1–10)	6 [5–7]	6 [5–7]	>0.9
Practicing a diet	44 (17.1)	37 (17.5)	0.9
Practicing a diet prescribed by a doctor	11 (25)	8 (21.6)	0.7
Dietary habits			
Fruit and vegetables (≥5/day)	7 (2.7)	4 (1.9)	0.8
Fruit or Vegetable (≥1/day)	153 (72.5)	181(70.2)	0.6
Legumes (≥2/week)	162 (62.8)	133 (63.0)	>0.9
Whole grains (≥1/day)	32 (12.4)	25 (11.9)	0.9
Dairy products (2/day)	52 (20.5)	30 (14.2)	0.092
Red meat (≤5/week)	256 (99.2)	209 (99.0)	>0.9
Fish (2/week)	100 (38.8)	84 (39.8)	0.8
Vegetable-origin fats	209 (81.0)	154 (73.0)	0.039
Limit sweetened foods (≤1/day)	138 (65.4)	175 (67.8)	0.6
Sweetened beverages (≤1/day)	179 (84.8)	214 (83.0)	0.6
Limit alcohol (≤1/week)	120 (56.9)	148 (57.4)	>0.9
Limit salt (≤1product/day)	169 (80.1)	203 (78.7)	0.7
Limit snacking (≤1/day)	191 (90.5)	229 (88.8)	0.5
Ready-made meals (≤3/week)	182 (86.3)	235 (91.1)	0.10
Sleep time per night (hours)			0.4
< 6	41 (19.4)	62 (24.0)	
[6 – 8]	143 (67.8)	152 (58.9)	
> 8	27 (12.8)	44 (17.1)	
Sleep quality			0.4
No or mild insomnia	175 (82.9)	206 (79.8)	
Moderate or severe insomnia	36 (17.1)	52 (20.2)	
Physical activity (≥30 min/day)	226 (87.6)	182 (86.3)	0.7
Elevated waist circumference *	168 (84.4)	137 (84.1)	>0.9
Missing	59	48	
Body Mass Index (kg/m^2)			0.6
<25	48 (18.7)	46 (22.2)	
[25–30[	106 (41.2)	78 (37.7)	
≥30	103 (40.1)	83 (40.1)	
Missing	1	4	
Cardiovascular diseases **	32 (12.4)	22 (10.4)	0.5
Dyslipidemia	108 (41.9)	75 (35.5)	0.2
Hypertension	130 (50.4)	87 (41.2)	0.05
Smoking status			0.5
Smokers	27 (14.4)	25 (18.4)	
Former smokers	72 (38.5)	55 (40.4)	
Non smokers	88 (47.1)	56 (41.2)	
Missing	71	75	
Musculoskeletal impairment	141 (54.7)	96 (45.5)	0.05
Physical restrictions	71 (27.5)	48 (22.7)	0.2
General health (scale 1–10)	6.9 ± 1.9	7.1 ± 1.7	0.3
Health compared to peers (scale 1–10)	7.0 ± 2.2	7.2 ± 1.9	0.4
1st degree familial diabetes ***	189 (73.3)	141 (66.8)	0.13

* Elevated waist circumference is defined as ≥ 94 cm for men; ≥80 cm for women.

** Cardiovascular diseases include stroke, coronary insufficiency, obliterating arteriopathy of the lower limbs, heart failure, carotid stenosis, coronary revascularization

*** 1st degree familial diabetes involves the father, mother, brothers, sisters. Categorical variables are expressed as n (percentages) and quantitative variables

as means ± standard deviation or Median [IQR]. P-values were calculated using Student's *t*-test or Wilcoxon rank-sum tests for continuous variables (depending on data distribution) and Chi-square test or Fisher's exact test for categorical variables.

Table 4
Association of lifestyle habits, sociodemographic and medical characteristics with prediabetes diagnosis status (already known vs. newly diagnosed) among adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469): age- and sex-adjusted analysis.

Lifestyle habits	OR[1]	95 % CI[1]	p-value
Perceived balance of nutrition (scale 1–10)	0.97	0.88, 1.07	0.6
Practising a diet	0.98	0.60, 1.60	>0.9
Dietary habits			
Fruit and vegetables (≥5/day)	1.47	0.43, 5.78	0.6
Fruit or Vegetable (≥1/day)	0.84	0.58, 1.23	0.4
Legumes (≥2/week)	1.05	0.71, 1.55	0.8
Whole grains (≥1/day)	0.99	0.56, 1.76	>0.9
Dairy products (2/day)	1.22	0.75, 1.98	0.4
Red meat (≤5/week)	0.97	0.11, 8.32	>0.9
Fish (2/week)	0.90	0.61, 1.32	0.6
Vegetable-origin fats	1.73	1.11, 2.71	0.016
Limit sweetened foods (≤1/ day)	1.09	0.73, 1.61	0.7
Sweetened beverages (≤1/day)	0.75	0.45, 1.25	0.3
Limit alcohol (≤1/week)	1.01	0.67, 1.50	>0.9
Limit salt (≤1product/day)	0.89	0.56, 1.40	0.6
Limit snacking (≤1/day)	0.75	0.40, 1.38	0.4
Ready-made meals (≤3/week)	1.26	0.68, 2.33	0.5
Sleep time per night (hours)			
< 6	—	—	
[6 – 8]	0.75	0.47, 1.18	0.2
> 8	1.03	0.55, 1.95	>0.9
Sleep quality			
No or mild insomnia			
Moderate or severe insomnia	1.27	0.79, 2.07	0.3
Physical activity *(≥30 min/day)*	1.07	0.61, 1.85	0.8
Elevated waist circumference *	1.00	0.55, 1.81	>0.9
Body Mass Index (kg/m^2)			
≥30	—	—	
[25–30[	0.93	0.60, 1.44	0.8
<25	0.70	0.41, 1.17	0.2
Cardiovascular diseases**	1.07	0.59, 1.96	0.8
Dyslipidemia	1.03	0.65, 1.62	>0.9
Hypertension	1.14	0.70, 1.84	0.6
Smoking status			
Non smokers	—	—	
Smokers	0.80	0.41, 1.54	0.5
Former smokers	0.84	0.51, 1.39	0.5
Musculoskeletal impairment	1.40	0.97, 2.03	0.075
Physical restrictions	1.26	0.82, 1.94	0.3
General health (scale 1–10)	0.92	0.83, 1.02	0.10
Health compared to peers (scale 1–10)	0.94	0.86, 1.03	0.2
1st degree familial diabetes***	1.26	0.85, 1.85	0.2

* Elevated waist circumference is defined as ≥ 94 cm for men; ≥80 cm for women.

** Cardiovascular diseases include stroke, coronary insufficiency, obliterating arteriopathy of the lower limbs, heart failure, carotid stenosis, coronary revascularization

*** 1st degree familial diabetes involves the father, mother, brothers, sisters. Categorical variables are expressed as n (percentages) and quantitative variables as means ± standard deviation or Median [IQR]. Odds ratios (OR) with 95 % confidence intervals (CI) were calculated using logistic regression. All associations were adjusted for age and sex.

those recently diagnosed, no difference was observed concerning their level lifestyle habits. For the all population, dietary habits were far from the national guidelines for the consumption of fruits, vegetables or whole grains. A large majority of participants limited their consumption of sweetened foods to one product per day (66.7 %) and 83.8 % drank sweetened beverages less than once a day. The consumption of salt and snacks was also rare (less than once a day for 79.3 and 89.6 % respectively). The dietary habits of subjects with already known or newly diagnosed prediabetes were similar concerning the consumption of fruit or vegetables, legumes, whole grain products, dairy products, sweetened food or beverages, snacking or ready-made meals. The only notable exception was a statistically significant but limited difference in the consumption of vegetable fats origin (81.0 % for the already known vs 73.0 % for the newly diagnosed; p = 0.039) [Table 3]. The prescription of a specific diet and the perception of the balance of their diet were also similar between the two populations. Regarding physical activity, 87.0 % of the participants declare having physical activity in line with national recommendations of 30 min/ day. The majority of physical activity was due to home activity (housework and gardening). Upon excluding all domestic activities, only 11.5 % of the participants were considered active (≥ 30 min/day of physical activity) and 10.7 % of the participants were considered highly active (≥ 60 min/day of physical activity). Again, no difference was found between population with already known diabetes and population with newly diagnosed diabetes. The same conclusion was made for quality of sleep with the majority of participants having an average sleeping time between 6 and 8 h per night (62.9 %) as recommended.

Taking into account the age differences, the association between lifestyle habits, sociodemographic and medical characteristic were measured after adjusting for age and sex. Again, the only statistically significant association between prediabetes status (already know vs. newly diagnosed prediabetes) and the different parameters was vegetable-origin fats (OR = 1.73, p-value = 0.016). No other significant differences in lifestyle habits, including physical activity and sleep, were observed between the groups [Table 4].

4. Discussion

The findings from this study offer a detailed and comprehensive overview of the health, socioeconomic conditions and lifestyle habits among subjects at very high risk to become diabetic because of a diagnosis of prediabetes made by their personal general practitioner in the context of Reunion Island. The clinical relevance of this research lies not only in its analysis of current health patterns but also in its potential to guide targeted interventions in primary care.

Reunion Island presents a unique and highly interesting context for diabetes study and prevention for several reasons. First, its diverse population acts as a microcosm of worldwide diversity (Dubut et al., 2009). Second, as a French department, it benefits from the same level of social protection as in mainland France, including similar healthcare coverage and a specific regional plan for diabetes care. Nevertheless, Reunion Island faces greater social disparities and higher level of precariousness reflecting a broader social diversity (Govind Y. Post-colonial Trends of Income Inequality: Evidence from the Overseas Departments of France. Available SSRN 4575893 [Internet]., 2020). Additionally, it has the highest diabetes prevalence in all France, making this condition a priority (Ricquebourg M, Kwan C, Médevielle S, Chopinet-Dijoux S, Caliez F, Thouillot F, et al. Prevalence of known diabetes in Reunion island, care and characteristics of the population: data from the, 2021). These factors make Reunion Island an invaluable site for observational and experimental studies in the context of the diabetes pandemic.

4.1. Socioeconomic discrepancies and their health Implications

In Reunion Island, marked socioeconomic disparities undeniably affect health outcomes, mirroring global trends that underscore the health disparities between groups. This is particularly evident in the differences observed between men and women in terms of employment and financial stability, reflecting a broader pattern of inequality (Marmot, 2005 Mar 19). Such discrepancies often translate into limited access to healthcare services, potentially leading to exacerbated health conditions (Braveman et al., 2011). Financial stress, an indirect outcome of socioeconomic disparities, has been closely associated to numerous health complications, including diabetes, obesity, cardiovascular diseases and mental health disorders (Wolfe, 2022 Jul; Guan et al., 2022

Feb 22). Furthermore, individuals with limited economic resources might face barriers in accessing preventive services, optimal medications, or even basic healthcare needs (Adler and Newman, 2002). This is emphasized by the fact that socioeconomic stressors can often lead to behavioral risk factors, such as poor diet and tobacco use, which in turn, aggravate health disparities (Stringhini et al., 2010 Mar 24).

From a clinical perspective, understanding these socioeconomic disparities is essential. It provides a comprehensive framework for global patient care, enabling healthcare professionals to consider both clinical symptoms and external stressors when making a management plan. This underscores the need for interventions and strategies that are both accessible and practicable for individuals facing socioeconomic hardship. Tailored interventions adapted to socioeconomic context, can provide better health outcomes and may alleviate negative impacts of economic vulnerabilities (Closing the gap in a generation: health equity through action on the social determinants of health - Final report of the commission on social determinants of health [Internet]. [cited, 2024).

4.2. Age, health behaviors and Implications for interventions

The correlation between age and health behaviors identified in our research aligns with established patterns, showing how health habits are influenced across different stages of life. Notably, the higher incidence of smoking among younger participants aligns with global observations, marking a persistent health challenge within this demographic (Lovato et al., 2011).

Additionally, the elevated BMI observed among younger participants raises alarm. This is consistent with the growing epidemic of obesity in younger populations globally, which is a major risk factor of diabetes (Wang et al., 2022 Feb). This underscores the urgency of targeted interventions for younger individuals.

As expected, older participants in our cohort were more likely to have conditions such as prediabetes, high blood pressure and dyslipidemia. This aligns with the natural course of aging where the risk of various health issues arises. However, despite these conditions, older participants reported a better self-perception of health, a finding which could reflect greater resilience or better coping mechanisms developed with age (Lima et al., 2023 Sep 8; Lau SYZ, Guerra RO, Barbosa JF de S, Phillips SP. Impact of resilience on health in older adults: a cross-sectional analysis from the International Mobility in Aging Study (IMIAS). BMJ Open., 2018).

The relative younger mean age in our cohort align with an earlier onset of diabetes observed in Reunion Island (Anthony et al., 2021 Jul). Moreover, the genetic predisposition to diabetes, indicated by the higher percentage of younger participants with a first-degree relative with diabetes, highlights the complex relationship between genetics, age, and environmental factors (Cole and Florez, 2020 Jul).

4.3. Clinical interventions and Policy Implications

Our study found no differences in dietary habits and physical activity between individuals with previously diagnosed prediabetes and those newly diagnosed. Modification of lifestyle habits are the cornerstone to avoid evolution from prediabetes to diabetes (Skoglund et al., 2022 Mar 21; Tuso, 2014). This emphasizes the need for targeted management strategies and increased awareness effort for diagnosis and care of prediabetes in the setting of primary care. Our study offers a roadmap to define more efficient intervention:

The FINDRISC score is the recommended tool in France, as in other countries, for identifying individuals at elevated risk of diabetes or prediabetes (Gabriel et al., 2021 Aug). A prior investigation conducted in Reunion Island revealed that the majority of general practitioners does not utilize this score to ascertain which subjects would benefit from diabetes screening (Montee et al., 2022 Apr). In this study, the prevalence of FINDRISC scores $\geq$ 12 among individuals with prediabetes suggests that general practitioners are attuned to the principal risk factors for diabetes and intuitively screen their patients based on these criteria. A more systematic screening using FINDRISC score from younger ages will allow better detection and care and can help prevent progression to more severe state of the disease and save money in the long term (Herman et al., 2015 Aug).

Currently, primary care physicians feel unequipped for diabetes prevention due to time constraints, and issues perceived as beyond their medical responsibility, such as addressing socioeconomic determinants (e.g., poverty, nutritional and physical activity environments). We highlight that socioeconomic differences, especially in women, and younger population need more attention. By looking at factors like education, job opportunities and social isolation, we can define targeted intervention to reduce these gaps (Hahn and Truman, 2015). Moreover, acknowledging mental health and physical disability as a crucial components is essential for obtaining a comprehensive understanding of an individual's overall well-being, albeit this process requires additional time and attention (Das et al., 2016 Oct). There's a pressing need to develop strategies, including tailored educational therapy programs (ETP) closer to patients, to support primary care practitioner in their care of subjects at risk to develop diabetes. Emerging technology like health apps and wearable devices, can be a focus in upcoming studies for their potential role in addressing these issues (Rhee et al., 2020 Dec).

Overall, broader research and novel technologies can help refine health strategies and provide healthcare professionals with support tools, leading to more efficient patient outcomes.

5. Conclusion

Our study raises new issues to address in the prevention of diabetes targeting prediabetes. Our findings point towards the necessity for interventions that consider social vulnerability especially gender and age-specific disparities. Gender-based approaches, particularly for women, should be prioritized given their unique health challenges and socioeconomic vulnerabilities. Age is a significant determinant of health outcomes as hypertension and T2D. However, our work underscores the importance of targeting the younger populations exhibiting risk factors for diabetes, specifically those under 45, through the implementation of adapted preventive measures and interventions and regular health assessments. By focusing on younger age groups, we can aim to reduce the risk factors associated with diabetes from an earlier stage in life (Bloetzer et al., 2015 Nov 5; Noubiap and Nyaga, 2023 Sep 7; Chrysant, 2011). Additionally, enhancing awareness and understanding of prediabetes through public health campaigns could lead to earlier diagnosis and more proactive management, hence improving long-term health outcomes for those at risk.

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CRediT authorship contribution statement

René Bun: Writing – original draft. **Babacar Tounkara:** Formal analysis. **Sébastien Leruste:** Investigation. **Laurie Kichenapanaidou:** Investigation. **Mathilde Simonson:** Investigation. **Christine**

Kowalczyk: Investigation. **Jean-Marc Franco:** Investigation. **Catherine Marimoutou:** Writing – original draft, Methodology. **Estelle Nobécourt:** Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

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Appendix 1. . Sociodemographic characteristics and health data by age group (<45 vs. ≥ 45 years) of adult Reunionese subjects with prediabetes at inclusion in the PREDIABRUN cohort study (2019–2022, n = 469)

	≥ 45 years, N = 391	< 45 years, N = 78	p-value
Socio-demographic Data			
Age (years)	57 [52 – 64]	39 [35 – 42]	
Gender			0.7
Men	164 (41.9)	31 (39.7)	
Women	227 (58.1)	47 (60.3)	
Birthplace – Reunion Island	348 (89.0)	67 (85.9)	0.4
Marital status			0.023
Living with a partner	254 (65.0)	40 (51.3)	
Living alone	137 (35.0)	38 (48.7)	
Education level			<0.001
Primary education	195 (49.9)	10 (12.8)	
Secondary education	74 (18.9)	16 (20.5)	
Post-secondary or higher education	122 (31.2)	52 (66.7)	
Professional activity			
Employee	153 (39.1)	50 (64.1)	
Unemployed	144 (36.8)	28 (35.9)	
Retired	94 (24)	0 (0)	
Precariousness*	134 (34.3)	32 (41)	0.3
Renunciation care for financial reasons	41 (10.5)	8 (10.3)	>0.9
Smoking status			0.013
Current smokers	39 (13.8)	13 (31.7)	
Former smokers	115 (40.8)	12 (29.3)	
Non smokers	128 (45.4)	16 (39.0)	
Missing	*109*	*37*	
Health Data			
Elevated waist circumference *	251 (82.8)	54 (91.5)	0.094
Missing	88	19	
Body Mass Index (kg/m^2)			<0.001
<25	86 (22.3)	8 (10.3)	
[25–30[	166 (43)	18 (23.1)	
≥30	134 (34.7)	52 (66.7)	
Missing	5	–	
Cardiovascular diseases**	51 (13)	3 (3.8)	0.020
Dyslipidemia	164 (41.9)	19 (24.4)	0.004
Hypertension	196 (50.1)	21 (26.9)	<0.001
Known prediabetes	226 (57.8)	32 (41)	0.007
Musculoskeletal impairment	197 (50.4)	40 (51.3)	0.9
Physical restrictions	98 (25.1)	21 (26.9)	0.7
General health (scale 1–10)	7.1 ± 1.8	6.6 ± 1.9	0.041
Health compared to peers (scale 1–10)	7.2 ± 1.9	6.4 ± 2.3	0.002
Depression			0.3
None or Light	284 (72.6)	52 (66.7)	
Moderate or Severe	107 (27.4)	26 (33.3)	
1st degree familial diabetes***	264 (67.5)	66 (84.6)	0.003

**Elevated waist circumference is defined as ≥ 94 cm for men; ≥80 cm for women; **Cardiovascular diseases include stroke, coronary insufficiency, obliterating arteriopathy of the lower limbs, heart failure, carotid stenosis, coronary revascularization; ***1st degree familial diabetes involves the father, mother, brothers, sisters. Categorical variables are expressed as n (percentages) and quantitative variables as means ± standard deviation or Median [IQR]. P-values were derived from Wilcoxon rank-sum tests for continuous variables and Fisher's exact tests for categorical variables.*

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