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ORIGINAL ARTICLE

Prevalence of diabetes mellitus and prediabetes in the adult Romanian population: PREDATORR study†

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Abstract

Background: The PREDATORR (PREvalence of DiAbeTes mellitus, prediabetes, overweight, Obesity, dyslipidemia, hyperuricemia and chronic kidney disease in Romania) study is the first national study analyzing the prevalence of diabetes mellitus (DM) and prediabetes, and their association with cardiometabolic, sociodemographic, and lifestyle risk factors in the Romanian population aged 20–79 years.

Methods: This was an epidemiological study with a stratified, cross-sectional, cluster random sampling design. Sociodemographic, lifestyle, and anamnestic data were collected through self- and interviewer-administered questionnaires, and biochemical assays and oral glucose tolerance tests were performed.

Results: In all, 2728 participants from 101 clinics of general practitioners were randomly selected, with a probability proportional to population size according to the 2002 Romanian Census.

The participation rate was 99.6%. Impaired glucose regulation (prediabetes, known and unknown DM) was found in 28.1% of the study population. The overall age- and sex-adjusted prevalence of DM was 11.6% (95%CI 9.6%–13.6%), of which 2.4% (95%CI 1.7%–3.1%) had unknown DM. The prevalence of DM increased with age and was higher in men than in women. The age- and sex-adjusted prevalence of prediabetes was 16.5% (95%CI 14.8%–18.2%), with the highest percentage in the 60–79 year age group and in women. Obesity, abdominal obesity, dyslipidemia, low education level, and a family history of diabetes were associated with glucose metabolism disorders.

Conclusions: The PREDATORR study shows a high prevalence of impaired glucose regulation in the adult Romanian population, providing data on the prevalence of DM and prediabetes and their association with several risk factors.

Keywords: diabetes mellitus, epidemiology, prediabetes, Romania.

Significant findings of the study: The PREDATORR study is the first to assess the prevalence of prediabetes and diabetes (known and unknown) in a representative sample of the adult Romanian population.
What this study adds: The results are of high value for health authorities and can be used to help inform decision makers to initiate implementation of preventative programs that may reduce the economic burden of diabetes in Romania.

Introduction

The prevalence and incidence of diabetes mellitus (DM) are increasing worldwide, particularly in developing countries, in conjunction with increased obesity rates and an unhealthy lifestyle.[1,2] Diabetes mellitus is one of the most frequent metabolic diseases, with an estimated prevalence of 9% among adults ≥18 years of age in the general population.[3] According to the International Diabetes Federation (IDF), 382 million people were living with DM and 316 million were living with impaired glucose tolerance (IGT) worldwide in 2014.[4] Most of these were adults between 40 and 59 years of age, and therefore still or potentially active professionally.[4] Epidemiologic projections for 2035 predict an increase in the prevalence of DM of 55%.[4] The devastating micro- and macrovascular complications of DM are associated with high mortality, which has exhibited an increasing trend over the period 2005–12: 1.5 million deaths due to DM were reported worldwide in 2012,[3] an excess of 0.4 million compared with reports in 2005.[4] However, these figures are probably an underestimation of the true number of deaths caused by DM. Recently, the IDF estimated this figure to be as high as 5.1 million deaths.[4]

The social, economic, and medical implications of DM represent a real public health problem. The World Health Organization estimated that DM was responsible for 89 million disability-adjusted life-years in 2012, whereas healthcare costs for the treatment of DM and its complications were estimated to be US$548 billion in 2013 with a predicted increase to more than US$627 billion by 2035.[4]

The reported prevalence of DM and prediabetes varies between studies in Europe and worldwide.[1,2,5–7] These differences appear due to the methodology used for population selection, different diagnosis criteria in certain periods, or the frequency of risk factors for DM in the included populations. Clear signals related to the increasing prevalence of obesity and metabolic syndrome, especially among the young population (<40 years of age) were seen in recent years, so it is extremely important for both physicians and society as a whole to gain more accurate knowledge of metabolic diseases and their complications. Despite the importance of these studies for the development of prevention programs and resource programming, only a few national studies on the prevalence of DM and prediabetes conducted in Portugal, Iceland, and Spain are available in Europe.[5,6,8–13]

The prevalence of DM and other metabolic diseases in Romania has not been rigorously scientifically evaluated to date. Indirect assessments (e.g. statistics on prescriptions for targeted therapies) exist,[14] but the number of unreported and/or unknown cases cannot be estimated correctly. The most recent data, bearing the aforementioned caveats, come from the IDF, which estimated a prevalence of 9.3% in 2014.[14] Based on literature research and data from local national health surveys, Guariguata et al. estimated a prevalence of DM of 5.1% for 2013 in Romania and predicted an increase to 6.4% in 2035.[15] In 2010, data from the National Program for Diabetes showed that 803 489 patients were registered as beneficiaries, equivalent to a prevalence of 4.2%.[16]

For the first time in Romania we conducted a representative study including participants from the entire country, namely the national study on the PREvalence of DiAbeTes mellitus, prediabetes, overweight, Obesity, dyslipidemia, hyperuricemia and chRonic kidney disease in Romania (PREDATORR). The aim of the present study was to establish the prevalence of DM and prediabetes in the Romanian population aged 20–79 years and to evaluate the interrelationships between the glucose metabolism impairment phenotype and various cardiometabolic, sociodemographic, and lifestyle risk factors.

Methods

Study design and participants

The PREDATORR study (EudraCT number: 2012-004803-12) was a cross-sectional, population-based study that investigated the prevalence of DM, prediabetes, overweight and obesity, dyslipidemia, hyperuricemia, and chronic kidney disease (CKD) in the Romanian adult population. This survey was initiated and coordinated by the Romanian Society of Diabetes, Nutrition and Metabolic Diseases and the Romanian Society of Nephrology, and was conducted between December 2012 and February 2014.

A two-cluster sampling design was used to select first the 101 general practitioners (GPs; distributed equally in

all eight historical regions of Romania) from the public database of the National Health Insurance Agency and then the study participants, who were enrolled using automated random computer selection from the GPs' databases. In all, 2728 participants aged 20–79 years were proportionally enrolled based on the 2002 Romanian Census in order to have a sample representative of the Romanian population. Prior to enrolment, participants underwent screening procedures to assess their eligibility for the study based on the following criteria: age 20–79 years, born and residing in Romania, living for the past 10 years mainly in Romania, included on a GP's list, not pregnant, and not lactating.

Written informed consent was obtained from all study participants before they underwent any study-specific procedures. The PREDATORR study was conducted according to the applicable International Conference on Harmonisation (ICH)/Good Clinical Practice (GCP) standards (see http://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Efficacy/E6/E6_R1_Guideline.pdf, accessed 10 February 2015) and the World Medical Association Declaration of Helsinki–Ethical Principles for Medical Research Involving Human Participants (Seoul, Korea, October 2008; see http://www.wma.net/en/30publications/10policies/b3/17c.pdf, accessed 10 February 2015) and was approved by the Romanian National Ethics Committee. All eligible participants were invited to attend four examinations at their GP's office. During the first visit, baseline sociodemographic, lifestyle, and anamnestic data were collected, followed by physical examination. At the second visit, blood samples were drawn from subjects in a fasting state and spot urine samples were collected. The third visit was only for participants without previously known DM and for whom a diagnosis of DM could not be established at the second study visit. During the third visit, fasting blood samples for glycemia were drawn, HbA1c was determined and a standard oral glucose tolerance test (OGTT) was performed. Visit 4 was scheduled 3 months after the second visit and was only for participants without previously known CKD and for whom a diagnostic of CKD could not be established at the second study visit. During the fourth visit, spot urine samples and fasting blood samples were collected to calculate estimated glomerular filtration rate (eGFR) and the urinary albumin : creatinine ratio (ACR). Herein we report the data collected during the first, second and third study visits.

Sociodemographic, lifestyle, and anamnestic data

Information regarding sociodemographic (age, gender, education level, marital status), lifestyle characteristics (physical activity), and anamnestic data (family history of DM in first- and/or second-degree relatives, personal medical history of DM, hypertension, dyslipidemia and obesity, current antidiabetic, antihypertensive, or lipid-lowering therapy) were collected using an interviewer-administered questionnaire. Information regarding smoking was collected using a self-administered questionnaire. Education level was categorized as low (primary/secondary school) or high (college, high school, university). Participants were classified according to smoking status as non-smokers (participants who never smoked), current smokers (participants who had smoked more than one cigarette per day, daily or occasionally and had not stopped smoking), and former smokers (participants who had quit smoking). Participants who undertook physical activity less than 4 days/week were considered sedentary.

Clinical and biochemical measurements

During the physical examination, the following measurements were made using standard procedures: weight, height, waist and hip circumference, and systolic and diastolic blood pressure (SBP and DBP, respectively). Body mass index (BMI) and the waist : hip ratio (WHR) were calculated. Participants with a BMI of 25–29.9 kg/m^2 were categorized as being overweight and those with BMI ≥30 kg/m^2 were considered obese. Abdominal obesity was defined as a WHR >0.9 in men and >0.85 in women.

Hypertension was defined as SBP (mean of three measurements taken 1–2 min apart) ≥140 mmHg and/or DBP (mean of three measurements taken 1–2 min apart) ≥90 mmHg and/or taking antihypertensive treatment and/or a personal history of hypertension.

Fasting plasma glucose (FPG), total cholesterol (TC), triglycerides (TG), and high-density lipoprotein (HDL) cholesterol were determined using enzymatic methods. HbA1c was determined using the immunoturbidimetric method. Low-density lipoprotein (LDL) cholesterol levels were calculated using the Friedewald formula if total TG levels were <4.52 mmol/L (400 mg/dL). All biochemical analyses were performed at the Synevo Romania SRL laboratories according to standardized procedures.

The glucose metabolism impairment phenotypes (DM, prediabetes) were defined according to the 2012 American Diabetes Association (ADA) guidelines.[17] A diagnosis of DM was made on the basis of symptoms of hyperglycemia, FPG, HbA1c and 2-h plasma glucose during the standard OGTT, or self-reported diagnosis. Prediabetes was diagnosed on the basis of FPG, HbA1c, and 2-h plasma glucose during the standard OGTT, or self-reported diagnosis. Both FPG and HbA1c were

determined at the second study visit in all participants and at the third study visit only in participants without previously known DM in whom a diagnosis of DM could not be determined at the second study visit; the OGTT was performed at the third study visit only in participants without previously known DM in whom the diagnosis of DM could not be concluded at the second study visit.

The OGTTs were performed using 75 g anhydrous glucose in the morning in the fasting state.[18] Patients were asked to fast overnight, to avoid heavy physical activity on the day before the examination, and not to smoke before and during the test.

Hypertriglyceridemia was considered when TG levels were ≥1.7 mmol/L (150 mg/dL) or participants were receiving drug treatment for hypertriglyceridemia; hypo-HDL cholesterolemia was considered when HDL levels were <1 mmol/L (40 mg/dL) in men and <1.3 mmol/L (50 mg/dL) in women, or participants were receiving drug treatment for reduced HDL; hyper-LDL cholesterolemia was considered when LDL levels were ≥2.6 mmol/L (100 mg/dL) and/or participants were on statin therapy.

Statistical analysis

Power analysis based on the stratified design was performed using the Cochran–Mantel–Haenszel test. Assuming a 10% prevalence of DM in the target population, a global sample size of 2182 participants with complete data was required to achieve an 80% power at a two-sided α level of 0.05. Considering a 25% rate of incomplete data, a sample size of 2728 participants was to be enrolled to ensure the calculated sample size with complete data was available.

The global prevalence was adjusted for the age and sex structure of the adult Romanian population according to the newly available 2011 Romanian Census (see http://www.recensamantromania.ro/rezultate-2/, accessed 10 February 2015). A full analysis method was used in the case of missing data (incomplete questionnaires, absence of laboratory results etc.); this method takes full account of all available information without the distortion resulting from using imputed values.

Participants were categorized into four groups based on the glucose metabolism impairment phenotype: (i) normal glucose tolerance (NGT); (ii) prediabetes; (iii) known DM (previously self-reported diagnosis of DM); and (iv) unknown DM (new cases of DM, diagnosed during the study).

Univariate and multivariate analyses using multiple logistic regression were performed to identify relationships between DM or prediabetes and various risk factors; odds ratios (OR) with 95% confidence intervals (CI) are provided.

All analyses were stratified for age groups and gender. Two-tailed $P < 0.05$ was considered significant. Analyses were performed using SPSS version 19.0 (IBM, Armonk, NY, USA).

Results

Of the 2728 participants enrolled in the study, 2717 had complete data and were included in the analyses; 11 (0.4%) were lost to follow-up (did not attend Visits 2 or 3). The mean (± SD) age of the participants was 47.7 ± 15.1 years, with 38%, 37.1% and 24.9% of participants belonging to the 20–39, 40–59, and 60–79 year age groups, respectively; 47.9% of participants were men.

In the Romanian population aged 20–79 years, the overall prevalence of DM adjusted for age and gender was 11.6% (95% CI 9.6%–13.6%). Of these, 2.4% (95% CI 1.7%–3.1%) did not know they had DM and 9.2% (95% CI 7.9%–10.5%) were previously diagnosed with DM.

The prevalence of known and unknown DM increased significantly with age, the highest prevalence being in the 60–79 year age group (Table 1). The overall prevalence of prediabetes was 16.5% (95% CI 14.8%–18.2%), with the highest percentage observed in the 60–79 year age group (Table 1). There was a higher prevalence of DM in men than in women, whereas prediabetes was predominant in women (Table 1); 28.1% of participants had impaired glucose regulation (DM or prediabetes).

In univariate analysis, overweight, general and abdominal obesity, dyslipidemia (hypertriglyceridemia and hypo-HDL cholesterolemia), and a family history of DM were significantly associated with the presence of known DM (Table 2). Men had a 1.5-fold higher risk of having known DM than women ($P < 0.001$). Widowers had a 2.1-fold higher risk of having known DM than married individuals ($P < 0.001$), whereas single and divorced participants were less likely to have known DM than married participants. Findings also revealed that the presence of hyper-LDL cholesterolemia and smoking cessation were associated with 60% lower odds of having known DM ($P < 0.001$).

The presence of unknown DM and prediabetes was associated with overweight, general and abdominal obesity, dyslipidemia (hypertriglyceridemia and hypo-HDL cholesterolemia), and a low education level. Unknown DM was also associated with male gender, divorced status, and a family history of DM (Table 2). Smoking cessation was associated with 30% lower odds of having prediabetes (Table 2).

Table 1 Prevalence (%) of diabetes mellitus and prediabetes in the Romanian population aged 20–79 years, adjusted by population distribution (2011 Romanian Census; see http://www.recensamantromania.ro/rezultate-2/, accessed on 10 February 2015)

	Age group (years)			
	20–39	40–59	60–79	Overall
Total population				
NGT	90.2 (88.9–91.6)	67.8 (65.7–69.9)	50.2 (47.9–52.5)	71.9 (69.9–73.9)
Prediabetes	6.9 (5.8–8.1)	18.9 (17.1–20.7)	27.8 (25.8–29.8)	16.5 (14.8–18.2)
Known diabetes	2.7 (2.0–3.4)	10.1 (8.7–11.5)	17.7 (16.0–19.4)	9.2 (7.9–10.5)
Unknown diabetes	0.2 (0.0–0.4)	3.2 (2.4–4)	4.3 (3.4–5.2)	2.4 (1.7–3.1)
Men				
NGT	88.4 (86.7–90.1)	64.5 (63.1–65.9)	49.7 (48.6–50.8)	70.1 (68.0–72.2)
Prediabetes	8 (7.5–8.6)	18.5 (17.7–19.3)	26.1 (25.3–26.9)	16.3 (14.6–18.0)
Known diabetes	3.5 (3.1–3.9)	12.1 (11.5–12.8)	19.7 (19.0–20.4)	10.7 (9.3–12.1)
Unknown diabetes	0.0	4.9 (4.5–5.3)	4.6 (4.3–4.9)	2.9 (2.1–3.7)
Women				
NGT	91.9 (90.2–93.6)	70.6 (69.0–72.2)	50.7 (50.6–51.8)	73.5 (71.5–75.5)
Prediabetes	5.7 (5.2–6.2)	19.2 (18.3–20.1)	29.3 (28.4–30.2)	16.7 (15.0–18.4)
Known diabetes	1.9 (1.6–2.2)	8.4 (7.8–9.0)	15.9 (15.3–16.6)	7.9 (6.7–9.1)
Unknown diabetes	0.5 (0.4–0.6)	1.8 (1.5–2.1)	4.1 (3.8–4.4)	1.9 (1.3–2.5)

Data show adjusted percentages, with 95% confidence intervals in parentheses.
NGT, normal glucose tolerance.

Multivariate logistic regression analysis showed that male gender, overweight, general and abdominal obesity, hypertriglyceridemia, widowed status, and a family history of DM were independent predictors for the presence of known DM, whereas for unknown DM only BMI ≥25 kg/m^2, abdominal obesity, and a family history of DM were independent predictors (Table 3). We observed that known DM had lower odds of being associated with hyper-LDL cholesterolemia. Prediabetes was independently associated with overweight, general and abdominal obesity, and a low education level (Table 3). Celibacy was an independent protective factor for prediabetes and smoking cessation was an independent protective factor for known DM (Table 3). In both regression analyses, NGT was considered as the reference category.

Discussion

The PREDATORR study was the first national study to systematically assess the prevalence of DM in the Romanian adult population. The study showed a DM prevalence of 11.6% and a prediabetes prevalence of 16.5%. The prevalence of DM was higher in men than women and in the elderly, data that are similar to those obtained in other studies.[5,6]

The overall prevalence of DM in the Romanian adult population was lower than that reported in earlier studies performed using a similar methodology in Spain (13.8%)[6] and Portugal (13.0%),[5] but the figure falls within the range reported by several studies that showed a moderate to low (10%–20%) prevalence of glucose metabolism disorders in European countries.[1,7] However, DM prevalence in Romania was higher than worldwide (8.3%) and global European (7.9%) DM prevalence published in 2014 by the IDF,[1] and higher than the DM prevalence in the US (9.3%).[2] The differences may be explained by the different study methodologies, different diagnostic criteria for glucose metabolism disorders, or different prevalence of risk factors for DM in different populations included in the evaluations.

According to the 2014 IDF Diabetes Atlas, Romania is ranked 13th of European countries, with a known national prevalence of DM of 9.2%.[4] The results of the present study showed a prevalence of known DM of 9.2%, confirming the data in the 2014 IDF Diabetes Atlas.

We identified 2.4% of the population with unknown DM (diagnosed during the study). With regard to the number of participants with DM in the PREDATORR study, 20.6% (one in five people with DM) were newly diagnosed and 79.4% had already been diagnosed with DM, revealing a detection rate superior to that reported worldwide (46.3%),[1] in Europe (33.1%),[1] and in the US (27.8%).[2] In addition, the percentage of cases of previously unknown DM we detected was lower than that reported in studies in Spain (6.0%) and Portugal (5.7%).[5,6] This higher detection rate in the Romanian population may be attributed to the "Prevention and

Table 2 Association of diabetes and prediabetes with cardiometabolic, sociodemographic, and lifestyle risk factors

	NGT	Prediabetes	Known DM	Unknown DM
No. participants	1953	449	250	65
Age (years)				
Mean ± SD	44.0 ± 14.5	55.8 ± 13.0	58.2 ± 12.0	58.7 ± 11.0
OR (95% CI)	1	1.0 (0.9–1.0)	0.9 (0.9–1.0)	0.9 (0.9–1.0)
Men				
%	45.3	48.4	56.0	58.2
OR (95% CI)	1	1.1 (0.9–1.4)	1.5 (1.2–1.9)***	1.7 (1.1–2.6)*
BMI (kg/m^2)				
25–29.99				
%	33.2	42.5	32.0	38.5
OR (95% CI)	1	3.3 (2.5–4.3)***	3.9 (2.6–5.7)***	6.7 (2.6–16.9)***
≥30				
%	24.8	43.0	56.4	52.3
OR (95% CI)	1	4.2 (3.2–5.6)***	7.9 (5.4–11.6)***	13.6 (5.5–34.0)***
Abdominal obesity				
%	56.9	76.6	85.1	93.8
OR (95% CI)	1	2.1 (1.7–2.7)***	4.5 (3.2–6.4)	9.7 (3.9–23.9)***
Hypertension				
%	62.3	62.1	63.9	64.1
OR (95% CI)	1	1.2 (1.0–1.4)	1.2 (0.9–1.5)	1.0 (0.7–1.6)
Hyper-LDL cholesterolemia				
%	76.4	82.6	65.4	81.7
OR (95% CI)	1	1.3 (1.0–1.6)	0.4 (0.3–0.5)***	0.7 (0.5–1.2)
Hypertriglyceridemia				
%	27.2	42.1	47.0	52.3
OR (95% CI)	1	1.7 (1.4–2.1)***	2.2 (1.8–2.8)***	3.1 (2.0–4.7)***
Hypo-HDL cholesterolemia				
%	27.3	35.1	43.8	42.2
OR (95% CI)	1	1.4 (1.1–1.7)**	1.8 (1.4–2.3)***	2.2 (1.4–3.4)***
Smoking status				
Current smoker				
%	28.3	20.9	15.3	20.0
OR (95% CI)	1	1.0 (0.8–1.3)	1.2 (1.0–1.6)	1.5 (0.9–2.4)
Former smoker				
%	24.1	26.6	34.7	36.9
OR (95% CI)	1	0.7 (0.5–0.9)**	0.4 (0.3–0.6)***	1.0 (0.5–1.8)
Sedentary				
%	20.5	16.6	22.4	13.8
OR (95% CI)	1	1.1 (0.9–1.4)	0.9 (0.6–1.1)	1.0 (0.6–1.8)
Marital status				
Widowed				
%	5.4	11.8	14.0	10.8
OR (95% CI)	1	1.4 (1.1–1.9)*	2.1 (1.5–2.8)***	1.7 (0.9–3.1)
Divorced				
%	5.6	4.9	3.6	6.2
OR (95% CI)	1	0.8 (0.5–1.3)	0.5 (0.3–1.0)*	2.5 (1.3–4.8)*
Single				
%	17.2	5.4	6.4	4.6
OR (95% CI)	1	0.4 (0.2–0.6)***	0.6 (0.4–1.0)*	0.6 (0.2–1.6)
Low education level				
%	8.7	15.2	13.3	15.9
OR (95% CI)	1	1.8 (1.4–2.3)***	1.3 (0.9–1.8)	1.8 (1.0–3.0)*
Family history of diabetes (yes)				
%	20.8	19.5	48.7	31.5
OR (95% CI)	1	0.9 (0.7–1.1)	3.6 (2.8–4.7)***	2.0 (1.2–3.3)**

Odds ratios (OR) were obtained by logistic regression adjusted for age and gender.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; LDL, low-density lipoprotein; HDL, high-density lipoprotein; NGT, normal glucose tolerance.

Table 3 Predictive factors for diabetes and prediabetes (multivariate logistic regression)

	Prediabetes	Known DM	Unknown DM
Male gender	1.0 (0.8–1.3)	1.5 (1.1–2.1)*	1.7 (0.9–3.1)
Age	1.0 (0.9–1.0)	1.0 (0.9–1.0)	0.6 (0.3–1.1)
BMI (kg/m^2)			
25–29.99	2.3 (1.6–3.2)***	2.9 (1.8–4.7)***	3.9 (1.3–11.5)*
≥30	3.1 (2.2–4.3)***	4.8 (3.0–7.7)***	8.0 (2.8–23.4)***
Abdominal obesity	1.4 (1.1–1.8)*	2.4 (1.6–3.6)***	4.4 (1.6–12.0)**
Hypertension	1.4 (0.9–1.8)	1.3 (0.9–1.8)	1.1 (0.6–2.1)
Hyper-LDL cholesterolemia	1.3 (0.9–1.7)	0.4 (0.3–0.5)***	0.5 (0.3–0.8)
Hypertriglyceridemia	1.3 (1.0–1.6)	1.7 (1.2–2.3)**	1.5 (0.9–2.6)
Hypo-HDL cholesterolemia	1.0 (0.8–1.3)	0.9 (0.7–1.3)	0.9 (0.5–1.6)
Smoking status			
Current smoker	0.8 (0.6–1.0)	0.8 (0.6–1.2)	1.0 (0.5–1.8)
Former smoker	0.8 (0.6–1.1)	0.4 (0.2–0.6)***	1.1 (0.5–2.2)
Sedentary	1.1 (0.9–1.5)	0.9 (0.6–1.2)	1.1 (0.6–2.1)
Marital status			
Widowed	1.1 (0.8–1.6)	2.2 (1.5–3.3)***	1.2 (0.5–2.8)
Divorced	0.7 (0.4–1.1)	0.6 (0.3–1.3)	1.7 (0.7–4.2)
Single	0.5 (0.3–0.9)*	0.6 (0.3–1.2)	1.0 (0.4–2.9)
Low education level	1.7 (1.2–2.3)**	1.1 (0.8–1.7)	1.5 (0.7–3.1)
Family history of diabetes (yes)	0.8 (0.6–1.1)	3.3 (2.5–4.4)***	1.8 (1.03–3.1)*

Data show odds ratios, with 95% confidence intervals in parentheses.
Normal glucose tolerance was considered the reference category.
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
BMI, body mass index; DM, diabetes mellitus; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

Control in DM and Other Nutrition-Related Diseases" national health program, ongoing in Romania since 2005.[19]

The prevalence of prediabetes in the Romanian adult population (16.5%) was higher than that in the Spanish study,[6] where the prevalence of impaired fasting glucose and IGT isolated and combined was 14.8%, but was lower than the prediabetes prevalence reported in the Portuguese study (27%)[5] and in the US population (37%).[2] These results cannot be compared with those published by the IDF in 2013,[4] because only the global and European prevalence for IGT was reported.

When applying our estimates to the total Romanian population, we can estimate that there are currently approximately 2 million people with diagnosed and undiagnosed DM. Furthermore, over 3 million people have prediabetes, thus being at high risk of developing DM.[20] These numbers are in line with those reported for other European countries, like the UK, where 2.9 million people with DM were registered and where it was estimated that 850 000 have undiagnosed DM.[21] Moreover, it is estimated that 889 000 Bulgarians have glucose metabolism disorders, whereas in Poland 2.6 million people have DM.[22] Given the high DM prevalence, we believe that our results are important from both a country and European public health perspective and have important implications for the planning of resources and DM prevention strategies.

It is known that obesity, and especially abdominal obesity, is an important risk factor for the development of DM and prediabetes.[5,6] In a population-based study of 1412 participants assessed twice at an interval of 10 years, it was shown that increased BMI and waist circumference were associated with a linear increase in the risk of developing DM (a 1 kg/m^2 increase in BMI was associated with an 8.4% increased risk of developing DM; a 1 cm increase in waist circumference was associated with a 3.2% increased risk of developing DM).[23] As expected, in the PREDATORR study we observed the association between obesity (general and abdominal) and the presence of all forms of impaired glucose regulation (prediabetes and both known and unknown DM).

Another factor associated with the presence of DM is education status. In univariate analysis, we observed an association between low education level and the presence of prediabetes and unknown DM, but in multivariate analysis this association persisted only for prediabetes. Studies evaluating the effect of education showed that a person with a lower education level had a higher risk of DM than people with a higher educational level.[1,5,6,24–26] In the National Health Interview Survey (1997–2002), people with a high school diploma or less had a 60%

higher risk of having DM than those with at least a Bachelor degree.[25] It was suggested that education level may contribute to the adherence to healthy lifestyle behaviors and thus to the prevention of DM.[27] The effect of education level is probably indirect; healthy lifestyle behaviors prevent weight gain and so education may contribute to the prevention of DM. In addition, education may promote other positive health behaviors, such as compliance with medication and changes in lifestyle once the disease is diagnosed.[27]

It should be noted that in both univariate and multivariate analyses we found that the presence of hyper-LDL cholesterolemia was associated with lower odds of having known DM. These observations are probably due to lifestyle interventions in this group and to the administration of statin therapy, which decreases LDL cholesterol.

The main strengths of the PREDATORR study are the representativeness of the sample for the adult Romanian population, the high study participation rate (99.6%), and, most importantly, the comprehensive diagnosis criteria for DM for all participants. In addition, the data were collected using an interviewer-administered questionnaire and all biochemical assays were performed in the same certified laboratory, thus reducing data recording errors.

Regarding the limitations of the study, new 2011 Census data became available after the start of the study, so participants were proportionally enrolled based on the 2002 Romanian Census. Nonetheless, to overcome this limitation, data were adjusted according to the results of the 2011 Romanian Census.

In conclusion, the PREDATORR study, for the first time, provides data for Romania on the prevalence of DM and prediabetes and their relationship with important risk factors in a representative sample of the Romanian adult population. These results are of high value for the health authorities and can be used to help inform decision making in order to initiate the implementation of prevention programs that may reduce the economic burden of DM in Romania.

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Disclosure

The authors declare no conflicts of interest.

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