

# Incidence of Diabetes in the Working Population in Spain: Results from the ICARIA Cohort

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## ABSTRACT

**Introduction:** Our objective was to evaluate the incidence of type 2 diabetes mellitus (T2DM) in a working population in Spain and to assess associations between its development and several risk factors.

**Methods:** The ICARIA (Ibermutuamur Cardiovascular Risk Assessment) cohort ( $n = 627,523$ ) includes ~3% of Spanish workers. This analysis was undertaken in individuals whose glycaemic status during the index period (May 2004–December 2007) was determined to be normal or

indicative of prediabetes [fasting plasma glucose (FPG) 100–125 mg/dl] and who had at least one FPG measurement taken 9 months after a first measurement during follow-up (May 2004–June 2014) ( $n = 380,366$ ). T2DM patients were defined as those with an FPG  $\geq 126$  mg/day and those who had already been diagnosed with T2DM or were taking antihyperglycaemic medications.

**Results:** The incidence rate of T2DM was 5.0 [95% confidence interval (CI) 4.9–5.1] cases per 1000 person-years. Under multivariate logistic regression analysis, the factor showing the strongest association with the occurrence of T2DM was the baseline FPG level, with the likelihood of T2DM almost doubling for every 5 mg/dl increase in baseline FPG between 100 and < 126 mg/dl. The presence of other cardiometabolic risk factors and being a blue-collar worker were also significantly associated with the occurrence of T2DM.

**Conclusions:** The incidence of T2DM in the working population was within the range encountered in the general population and prediabetes was found to be the strongest risk factor for the development of diabetes. The workplace is an appropriate and feasible setting for the assessment of easily measurable risk factors, such as the presence of prediabetes and other cardiometabolic factors, to facilitate the early detection of individuals at higher risk of diabetes and the implementation of diabetes prevention programmes.

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## INTRODUCTION

Diabetes mellitus carries a tremendous health-care burden. In 2017, the disease had a worldwide prevalence in adults of 8.8% and was associated with 4.0 million deaths and health expenditure of USD 727 billion [1]. The development of type 2 diabetes mellitus (T2DM), which accounts for the vast majority of diabetes mellitus cases, can be prevented or delayed through strategies that involve lifestyle modifications [2]. The lifestyle intervention Diabetes Prevention Program has been shown to lower the risk of developing diabetes by 58% compared with placebo; the comparative reduction achieved with metformin was 31% [3]. The workplace is of particular interest when implementing health-promotion programmes, such as those designed to decrease the risk of developing diabetes [4], allowing for the early diagnosis and close monitoring through annual check-ups of individuals who are at high risk of developing diabetes (e.g., have prediabetes). In addition, certain lifestyle interventions are suitable for implementation at the workplace.

Research into the incidence of T2DM in the working population is lacking. The incidence rate of diabetes among 6924 workers in Bangkok (Thailand) was 11.4 per 1000 person-years and was higher in males than in females (17.8 vs 9.2 per 1000 person-years) [5]. Incidence rates also vary depending on type of work and workers' ethnicity. Among Japanese white-collar employees, the incidence of diabetes per 1000 person-years was 6.0 for clerical workers, 6.1 for technical/professional employees, 8.8 for managers/administrative staff, and 9.4 for people working in sales [6]. The cumulative incidence was 13% for a median follow-up of 27.9 years in a population-based study conducted in Sweden [7], 7.1% for non-Danish workers of Western

origin, and 11.4% for those of non-Western origin in a 12-year follow-up Danish study [8]; the cumulative incidence of diabetes was higher among unskilled and semi-skilled manual occupations than among professionals [8]. Importantly, most of the individuals identified with T2DM in the workplace had not been previously diagnosed [9], and very few met combined targets for glycated haemoglobin (HbA<sub>1c</sub>), systolic blood pressure, and low-density lipoprotein (LDL) cholesterol [10].

Overall, information on the incidence of diabetes in the working population is scarce, and most studies have been conducted in Asia or Northern Europe. The primary aim of this longitudinal study was to evaluate the incidence of T2DM in a working population in Spain. Secondary objectives were to evaluate the incidence of T2DM in relevant clinical subgroups and to assess associations between the development of T2DM and several risk factors.

## METHODS

This was an analysis of the ICARIA (Ibermutuamur Cardiovascular Risk Assessment) prospective cohort study undertaken in an active working population in Spain. The ICARIA study was approved by the Ethics Committee of Ibermutuamur (Madrid, Spain), and all procedures were in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards. All participants provided written informed consent for their information to be included in anonymous aggregated analyses for this study. The ICARIA study methodology has been reported elsewhere [11]; this cohort was previously used to evaluate the prevalence of diabetes in the Spanish working population [12].

### Study Population

Subjects included in the ICARIA cohort were employees covered by two companies: Ibermutuamur and Cualtis. Ibermutuamur is a mutual insurance company for work-related accidents and occupational illnesses that covers over 1,000,000 workers in Spain [11]. Cualtis is a

company that focuses specifically on preventing diseases and accidents in the workplace, monitoring and promoting workers' health through routine, voluntary yearly medical examinations (some 500,000 workers are invited every year and approximately 300,000 undergo examination). Employees who underwent routine medical examinations with Cualtis between May 2004 and December 2007 (the index period) were included in the ICARIA database. In total, the ICARIA cohort included over 3% of the working population in Spain [13].

The population at risk in this analysis comprised individuals whose glycaemic status during the index period was determined to be normal or indicative of prediabetes, as defined below, and who had at least one fasting plasma glucose (FPG) measurement taken a minimum of 9 months after a first measurement during the follow-up period from May 2004 to June 2014. Individuals with an FPG < 100 mg/dl at first measurement were considered to have 'normal' fasting glycaemia, and those with an FPG 100–125 mg/dl were considered to have prediabetes. Those with an FPG  $\geq$  126 mg/dl who had already been diagnosed with T2DM or who were taking antihyperglycaemic medications were classified as having T2DM (i.e., cases of T2DM) and were excluded from the population at risk.

### Assessments

Check-ups included a structured questionnaire, physical examination, and laboratory analyses. The structured questionnaire collected demographic data, including specific occupation, lifestyle habits such as smoking status and alcohol consumption, and medical history. The physical examination included weight, height, waist circumference, and two blood pressure recordings from the same arm. Routine laboratory assays included FPG, uric acid, creatinine, triglycerides, total cholesterol, LDL cholesterol, and high-density lipoprotein (HDL) cholesterol.

### Statistical Analysis

The incidence rate was used to calculate the number of T2DM cases, as previously defined,

during the follow-up period, assuming a constant rate of disease events during the study period, and was expressed as cases per 1000 person-years. Incidence was calculated as the ratio of new T2DM cases (as previously defined) to the total time the population was at risk for disease [the time (in years) each person was observed from the first FPG measurement until final check-up or until a diagnosis of diabetes was made, totalled for all participants]. Incidence rates are presented with the corresponding 95% confidence interval (CI).

The baseline characteristics of the study population are reported as means and standard deviations (SDs) or medians and interquartile ranges (IQRs) for continuous outcomes and as absolute and relative frequencies for categorical outcomes.

A logistic regression analysis was applied to quantify the association between baseline characteristics and the occurrence of T2DM. Selection of variables for the multivariate analysis was performed using a forward stepwise approach. Goodness of fit was verified with the Hosmer-Lemeshow test. Missing data were not imputed and were excluded from the analyses; data were considered missing at random. The independent variables tested in the model included age (< 30, 30–39, 40–49, 50–59, or  $\geq$  60 years), sex, occupation [manual (blue collar) or non-manual (white collar)], smoking status [never smoked, former smoker (stopped smoking  $\geq$  1 year ago), or smoker (current smoker, under treatment for smoking cessation, or stopped smoking < 1 year ago)], alcohol consumption [never drinker or not currently drinking (standard drinks = 0) or current drinker (standard drinks > 0)], body mass index [BMI; underweight (< 18.5 kg/m<sup>2</sup>), normal weight (18.5–24.99 kg/m<sup>2</sup>), overweight (25.0–29.99 kg/m<sup>2</sup>), obese I (30.0–34.99 kg/m<sup>2</sup>), obese II (35.0–39.99 kg/m<sup>2</sup>), or obese III ( $\geq$  40 kg/m<sup>2</sup>)], waist circumference [normal ( $\leq$  102/88 males/females) or abnormal (> 102/88 males/females)], FPG (< 100, 100–< 105, 105–< 110, 110–< 115, 115–< 120, or  $\geq$  120–< 126 mg/dl), uric acid [low (< 3.5/2.6 mg/dl males/females), normal (3.5–7.2/2.6–6.0 mg/dl males/females), or high (> 7.2/6.0 mg/dl males/females)], triglycerides [normal (< 150 mg/dl) or abnormal

( $\geq 150$  mg/dl), HDL cholesterol [normal ( $> 40/50$  mg/dl males/females) or abnormal ( $\leq 40/50$  mg/dl males/females)], total cholesterol [normal ( $< 200$  mg/dl) or abnormal ( $\geq 200$  mg/dl)], and hypertension [blood pressure (systolic/diastolic)  $\geq 130/85$  mmHg, a previous diagnosis of hypertension, or receipt of treatment for hypertension].

All statistical analyses were performed using IBM SPSS Statistics version 17.0.0.

## RESULTS

### Participant Disposition and Characteristics

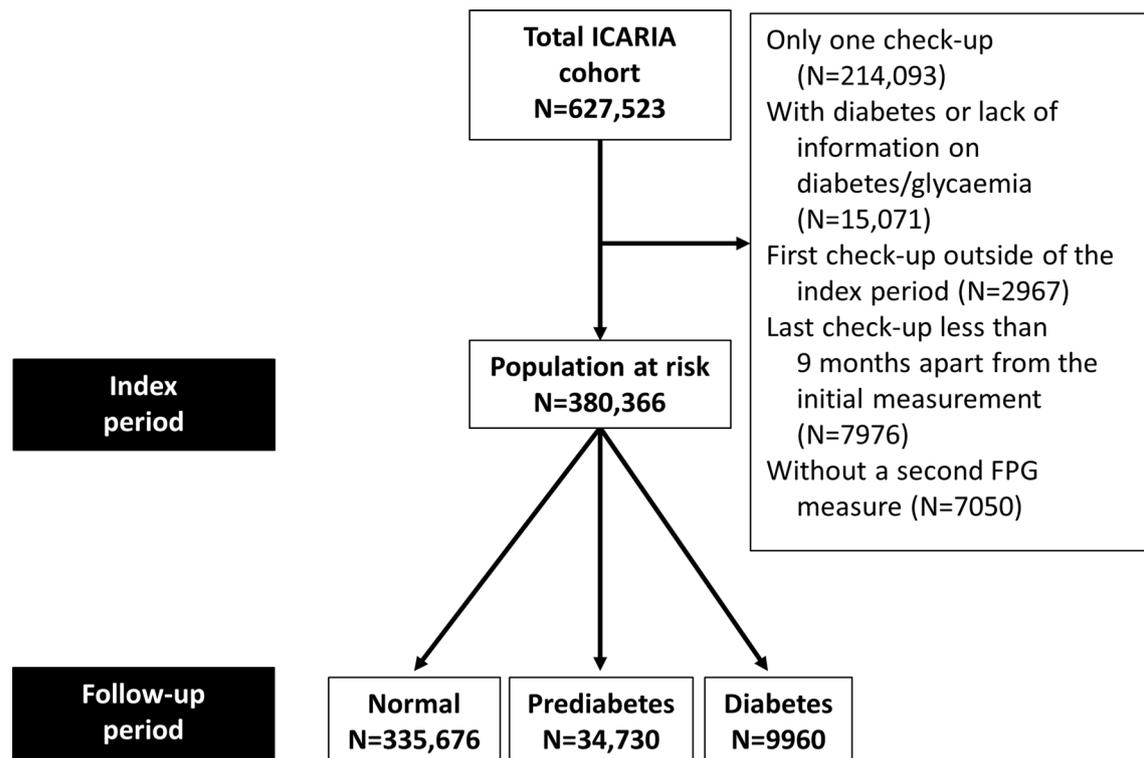
The ICARIA cohort included 627,523 individuals, 380,366 (60.6%) of whom met the selection criteria for inclusion in the population at risk for these analyses. The main reason for exclusion from the analyses was that the individual had undergone only one check-up (Fig. 1). Of the 380,366 individuals in the population at

risk, 345,555 (90.8%) had information for all independent variables chosen for the multivariate analysis and were included in this analysis.

The population at risk was predominantly male (71.6%), with a mean (SD) age of 36.4 (10.4) years. Median (IQR) follow-up was 4.1 (2.0–9.0) years. Demographic and clinical characteristics are presented in Table 1.

### Incidence of Diabetes

There were 9960 cases of T2DM during the follow-up period, yielding an overall incidence rate of 5.0 (95% CI 4.9–5.1) cases per 1000 person-years. Table 2 shows the incidence rates of diabetes for various subgroups. Incidence was higher in males [6.3 (95% CI 6.2–6.4) per 1000 person-years] than in women [1.9 (95% CI 1.8–2.0)]. Subgroups displaying the highest incidence were individuals with an initial FPG level of  $\geq 120$ – $< 126$  mg/dl, for whom incidence was 124.2 (95% CI 116.8–131.5) per 1000



**Fig. 1** Flow chart of study participants. FPG, fasting plasma glucose

**Table 1** Demographic and clinical characteristics of the subjects included in the population at risk

Characteristic	<i>N</i>	
Age (years)	380,366	36.4 ± 10.4
Sex (male)	380,366	272,497 (71.6)
Follow-up duration (years)	380,366	5.2 ± 3.6
Waist circumference (cm)	356,735	88.0 ± 12.7
Body mass index (kg/m <sup>2</sup> )	377,186	25.8 ± 4.2
Glycaemia (mg/dl)	380,366	88.0 ± 10.9
Uric acid (mg/dl)	380,295	5.4 ± 1.5
Creatinine (mg/dl)	380,170	1.01 ± 0.25
Total cholesterol (mg/dl)	380,364	196.7 ± 40.2
Triglycerides (mg/dl)	379,988	107.2 ± 80.5
High-density lipoprotein cholesterol (mg/dl)	377,796	53.3 ± 13.8
Low-density lipoprotein cholesterol (mg/dl)	376,961	122.3 ± 34.5
Heart rate (beats per minute)	367,377	70.6 ± 10.9
Systolic blood pressure (mmHg)	378,695	125.3 ± 16.3
Diastolic blood pressure (mmHg)	378,635	75.9 ± 10.7

Data are presented as mean ± standard deviation or *n* (%)

person-years; those with a BMI ≥ 40, with an incidence of 25.3 (95% CI 21.9–28.6) per 1000 person-years, and those aged ≥ 60, who exhibited an incidence of 24.9 (95% CI 17.9–31.9) per 1000 person-years. Furthermore, incidence was greater among blue-collar workers than among white-collar workers, in people with an abnormal waist circumference, current drinkers, smokers or former smokers, and individuals with dyslipidaemia or hypertension (Table 2).

### Factors Associated with the Occurrence of Diabetes

Under multivariate logistic regression analysis, the factor with the strongest association with the occurrence of T2DM was baseline FPG level (Table 3), with the likelihood of T2DM almost doubling for every 5 mg/dl increase in baseline FPG above 100 mg/dl (vs < 100 mg/dl), reaching an odds ratio (OR) of 27.41 (95% CI

24.86–30.22) in those with a baseline FPG of ≥ 120–< 126 mg/dl. The likelihood of diabetes also increased with BMI, with individuals with a BMI ≥ 40 kg/m<sup>2</sup> having an OR of 3.35 (95% CI 2.77–4.04) compared with those with a BMI < 18.50 kg/m<sup>2</sup>. The presence of other cardiometabolic risk factors, hyperuricaemia, and being a blue-collar worker were also significantly associated with the occurrence of T2DM (Table 3).

## DISCUSSION

The incidence of T2DM in a working population in Spain has not previously been studied. Our results suggest incidence is greater in males than in females and in blue-collar workers than in their white-collar counterparts. The factor most strongly associated with the occurrence of diabetes is a baseline FPG of 100–< 126 mg/dl (i.e., prediabetes).

**Table 2** Incidence of diabetes for the total cohort and for certain subgroups

Subgroup	Number of individuals at risk	Cases of diabetes	Incidence cases/1000 PY (95% CI)
Overall	380,366	9960	5.0 (4.9–5.1)
Sex	380,366	9960	
Female	107,869	1062	1.9 (1.8–2.0)
Male	272,497	8898	6.3 (6.2–6.4)
Age (years)	380,366	9960	
< 29	113,538	743	1.3 (1.0–1.7)
30–39	130,297	2062	2.9 (2.8–2.9)
40–49	88,362	3940	7.9 (7.7–8.1)
50–59	41,728	2844	15.4 (14.7–16.1)
≥ 60	6441	371	24.9 (17.9–31.9)
Occupation	380,053	9954	
White collar	143,339	2600	3.2 (3.1–3.3)
Blue collar	236,714	7354	6.3 (6.1–6.4)
Waist circumference	356,735	9263	
≤ 102/88 (male/female)	300,308	5372	3.3 (3.2–3.4)
> 102/88 (male/female)	56,427	3891	13.2 (12.8–13.6)
Body mass index (kg/m <sup>2</sup> )	377,186	9888	
< 18.50	5857	26	0.9 (0.6–1.2)
18.50–24.99	168,476	1581	1.8 (1.7–1.9)
25.00–29.99	147,006	4251	5.5 (5.3–5.6)
30.00–34.99	45,697	3025	13.2 (12.8–13.7)
35.00–39.99	8230	786	20.6 (19.2–22.0)
≥ 40.00	1920	219	25.3 (21.9–28.6)
Alcohol consumption	375,751	9763	
Never/not currently drinking	132,931	3024	4.4 (4.2–4.5)
Current drinker	242,820	6739	5.3 (5.2–5.5)
Smoking status	380,365	9960	
Never smoked	149,672	2766	3.4 (3.3–3.6)
Quit smoking ≥ 1 year ago	53,322	2088	7.3 (7.0–7.6)
Smoker or quit smoking < 1 year ago	177,371	5106	5.7 (5.6–5.9)

**Table 2** continued

Subgroup	Number of individuals at risk	Cases of diabetes	Incidence cases/1000 PY (95% CI)
Baseline FPG (mg/dl)			
< 100	329,433	4013	2.3 (2.2–2.4)
100–< 105	24,558	1295	10.3 (9.7–10.8)
105–< 110	13,280	1296	20.0 (18.9–21.1)
110–< 115	6767	1201	38.8 (36.6–41.0)
115–< 120	3787	1062	69.4 (65.2–73.6)
≥ 120–< 126	2541	1093	124.2 (116.8–131.5)
Triglycerides (mg/dl)			
< 150	313,981	5847	3.6 (3.5–3.6)
≥ 150	66,007	4102	12.3 (11.9–12.6)
HDL (mg/dl)			
> 40/50 (male/female)	323,436	7710	4.6 (4.5–4.7)
≤ 40/50 (male/female)	54,360	2154	7.1 (6.8–7.3)
Total cholesterol (mg/dl)			
< 200	211,293	3712	3.4 (3.3–3.5)
≥ 200	169,071	6247	7.1 (6.9–7.2)
LDL (mg/dl)			
< 160	323,679	7513	4.4 (4.3–4.5)
≥ 160	53,282	2276	8.1 (7.8–8.5)
Blood pressure			
Normal	220,254	3026	2.6 (2.5–2.7)
Hypertension <sup>a</sup>	158,450	6886	8.6 (8.4–8.8)

<sup>a</sup> Hypertension was defined as blood pressure (systolic/diastolic) ≥ 130/85 mmHg, a previous diagnosis of hypertension, or receipt of treatment for hypertension  
CI, confidence interval; FPG, fasting plasma glucose; HDL, high-density lipoprotein; LDL, low-density lipoprotein; PY, person-years

The incidence rate of T2DM in this Spanish working population (5.0 cases per 1000 person-years) was lower than previously reported in studies among workers in Bangkok (Thailand) (11.4 cases per 1000 person-years [5]) or Japan (6.0–9.4 cases per 1000 person-years, depending on the type of work [6]). These differences are

not unexpected, since the epidemiological pattern of T2DM varies between ethnic groups, being up to six times more common in people of South Asian descent [14]. Unfortunately, we have no previous comparative data on the incidence of T2DM in a European working population that would enable us to

**Table 3** Multiple logistic regression, evaluating factors associated with the occurrence of diabetes in a working population

Variable	N	Odds ratio (95% CI)
Sex	345,555	
Female	97,611	1
Male	247,944	1.54 (1.42–1.66)
Age (years)	345,555	
< 30	102,725	1
30–39	119,236	1.73 (1.58–1.90)
40–49	80,460	3.42 (3.12–3.74)
50–59	37,604	3.68 (3.35–4.05)
≥ 60	5530	2.32 (1.99–2.71)
Occupation	345,555	
White collar	131,380	1
Blue collar	214,175	1.16 (1.10–1.22)
Body mass index (kg/m <sup>2</sup> )	345,555	
< 18.50	5300	1
18.50–24.99	154,212	0.75 (0.48–1.16)
25.00–29.99	135,053	1.49 (1.39–1.60)
30.00–34.99	41,772	2.00 (1.83–2.18)
35.00–39.99	7460	2.56 (2.27–2.89)
≥ 40.00	1758	3.35 (2.77–4.04)
Waist circumference (cm)	345,555	
≤ 102/88 (male/female)	291,079	1
> 102/88 (male/female)	54,476	1.47 (1.38–1.57)
Smoking status	345,555	
Never smoked	135,721	1
Quit smoking ≥ 1 year ago	48,814	1.08 (1.01–1.16)
Smoker or quit smoking < 1 year ago	161,020	1.45 (1.37–1.53)
Uric acid (mg/dl)	345,555	
Low (male/female < 3.5/2.6)	10,107	1
Normal	293,661	1.30 (1.06–1.59)
High (male/female > 7.2/6.0)	41,787	1.47 (1.19–1.81)
Baseline FPG (mg/dl)	345,555	
< 100	299,656	1
100–< 105	22,290	2.84 (2.65–3.04)

**Table 3** continued

Variable	N	Odds ratio (95% CI)
105–< 110	11,994	4.86 (4.52–5.23)
110–< 115	6074	8.66 (8.00–9.36)
115–< 120	3338	14.58 (13.34–15.93)
≥ 120–< 126	2203	27.41 (24.86–30.22)
Triglycerides (mg/dl)	345,555	
< 150	285,750	1
≥ 150	59,805	1.43 (1.36–1.51)
HDL (mg/dl)	345,555	
> 40/50 (male/female)	271,196	1
≤ 40/50 (male/female)	74,359	1.41 (1.33–1.48)
Total cholesterol (mg/dl)	345,555	
< 200	191,600	1
≥ 200	153,955	0.94 (0.90–0.99)
Blood pressure	345,555	
Normal	201,818	1
Hypertension <sup>a</sup>	143,737	1.31 (1.24–1.38)

<sup>a</sup> Hypertension was defined as blood pressure (systolic/diastolic) ≥ 130/85 mmHg, a previous diagnosis of hypertension, or receipt of treatment for hypertension

CI, confidence interval; FPG, fasting plasma glucose; HDL, high-density lipoprotein

contextualize our data. Patient subgroups that exhibited the highest incidence rates of T2DM in our study were consistent with those reported by Jiamjarasrangsri and Aekplakorn [5] in Thailand, who also found higher incidence rates in males than in females and that the incidence increased with age.

The working population could be expected to be younger and healthier than the general population and hence to have a lower incidence of T2DM than is found generally. Roughly in line with this expectation, the incidence rate of T2DM in our study sat within the lower limit of the wide range of rates reported in studies conducted in the general population in several regions of Spain. Reported rates range from

1.96–3.5 per 1000 person-years in central regions of Spain [15, 16] to 10.8 and 19.1 in northern [17] and southern regions [18], respectively. In addition to the setting, variations in the definitions of the population at risk and the criteria used to diagnose T2DM may account for these differences in the incidence rates of T2DM throughout Spain.

Of all the factors associated with T2DM identified in our study, an FPG level of 100–< 126 mg/dl at baseline had the strongest association, with the risk of T2DM almost doubling for every 5 mg/dl increase in FPG between 100 and < 126 mg/dl (vs < 100 mg/dl), thus supporting previous findings that prediabetes (in our study as defined by FPG) is the leading risk

factor for the development of T2DM [19]. The association between the lowest level of FPG (100–< 110 mg/dl) and the occurrence of diabetes was stronger than that for many of the other cardiometabolic risk factors. This finding is consistent with the results of the previously mentioned Thai study, which found FPG levels of 100–125 mg/dl (vs FPG < 93 mg/dl) to be associated with an incidence rate ratio for T2DM of 31.5 [5]. It is also consistent with the results of two previous studies investigating the incidence of T2DM in the general population in Spain that found baseline FPG or the presence of prediabetes to be the strongest predictor of T2DM [15, 17]. Notably, among individuals with prediabetes, those with the lowest FPG (i.e., 100–< 105 mg/dl) displayed an almost threefold increase in the likelihood of developing diabetes. This is highly relevant to diabetes prevention campaigns, because, as has been stated, ‘it is only through the prompt diagnosis of prediabetes and implementation of lifestyle changes very early in its denouement that we can hope to forestall the development of diabetes and its associated complications, thus decreasing the burden on the individual and on society’ [20]. In our opinion, the workplace is an important—if not ideal—setting in which to implement such prediabetes diagnostic and intervention programmes. Routine medical examinations at work, involving a simple and low-cost test such as FPG, and preventive initiatives in this setting would be especially helpful in the diabetes area as many individuals with—or at risk of developing—the condition are unaware of any potential problem. In the most recent population-based study of the prevalence of diabetes in Spain, almost half of the patients found to have the disease were unaware of their diagnosis [21]. In addition, workers are considered to be a healthy population and hence less likely to visit their family physician, thus potentially missing out on the opportunity of being included in prediabetes screening programmes or other such preventive activities. The workplace also facilitates group-based interventions and can make specific measures possible, such as promoting healthier eating at sites with catering facilities. A recent study has shown that implementing a short-

term programme consisting of dietary counselling and participation in physical activity among workers with prediabetes reduced the prevalence of prediabetes by more than 30% after 12–16 weeks [22].

Should we focus only on prediabetes as a target risk factor? Despite our findings that the association between other factors, such as central obesity, dyslipidaemia, and hypertension, and the occurrence of T2DM is much lower than that between prediabetes and T2DM, the coexistence of these factors has been shown to increase substantially the likelihood of developing T2DM. A study in 55,271 Japanese workers with a median follow-up of almost 5 years revealed that the hazard ratio for developing T2DM among individuals with prediabetes rose from 17.6 in those with one additional component of the metabolic syndrome to 40.7 in those with four additional components [23]. Hyperuricaemia and smoking are established risk factors for T2DM [6, 24] and were also associated with the occurrence of T2DM in this study. Hyperuricaemia may also exhibit a bidirectional causal relationship with insulin resistance [24], which is part of the metabolic syndrome [25]. It therefore seems essential that diabetes prevention programmes adopt an integrative approach that addresses all these factors to maximise their effects on decreasing the risk of developing T2DM.

Our results indicate that type of work is also a risk factor for developing diabetes, with the risk of T2DM being higher among blue-collar workers than among white-collar workers. Similar differences in risk of diabetes between professionals and unskilled workers were reported by Poulsen et al. [8] in a 12-year follow-up Danish study. However, this broad categorization into blue- and white-collar workers may not be especially useful when designing preventive programmes, as the risk of T2DM has been shown to vary within the same occupational category, as reported among white-collar workers in Japan [6].

Strengths of this study include the sample size and that the ICARIA cohort includes ~3% of Spanish workers. Participants are derived from all occupational sectors and geographical regions of the country and can, therefore, be

considered representative of the Spanish working population [11]. Study limitations include that our criteria for defining T2DM [i.e., a single FPG measurement  $\geq 126$  mg/dl, a previous diagnosis of T2DM, or receipt of current anti-hyperglycaemic treatment, a definition used in a number of other studies [5, 6], may have overestimated the frequency of diabetes (and prediabetes)]. In a study conducted among workers from Bangladesh, the prevalence of diabetes and prediabetes was higher when evaluated by means of FPG rather than an oral glucose tolerance test (for prediabetes, prevalence was 31.8% and 13.7%, respectively) [27]. In addition, HbA<sub>1c</sub> and oral glucose tolerance tests were not included in the routine annual examinations carried out in this study, and these parameters could have provided useful information regarding the definition of diabetes and prediabetes.

## CONCLUSION

This study, the first to assess the incidence of T2DM in a large, representative sample of a working population in southern Europe, found the incidence of T2DM to be within the range encountered in the general population. Prediabetes, as assessed as an FPG of 100–< 126 mg/dl, was found to be the strongest risk factor for the development of diabetes, although other cardiometabolic risk factors also contributed to its occurrence. Our results support the workplace as an appropriate and feasible setting for the assessment of easily measurable risk factors, facilitating the early detection of individuals at higher risk of diabetes and the implementation of diabetes prevention programmes.

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**Compliance with Ethics Guidelines.** The ICARIA study was approved by the Ethics Committee of Ibermutuamur (Madrid, Spain) and all procedures were in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All the participants provided written informed consent to include their information in anonymous, aggregated analyses for this study.

**Data Availability.** The data sets generated and/or analysed during the current study are not publicly available. All of the relevant data are included in this published article and its supplementary information files.

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