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Incidence of type 2 diabetes in the elderly in Central Spain: Association with socioeconomic status, educational level, and other risk factors

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ABSTRACT

Aims: To analyze the incidence of type 2 diabetes (T2D) in Central Spain and its association with the socioeconomic status (SES), educational level, and other risk factors (RF) in the elderly population of three communities.
Methods: Data for 5278 elderly participants (≥65 years old) were obtained using a census population-based survey. There was a first and a second survey three years later. The association between SES, educational level, RF, and T2D incidence was analyzed.
Results: The incidence rate for T2D was 9.8/1000 person-years without gender differences. Incident T2D was associated with low SES and lower educational levels. Baseline and follow-up BMI were also the main RFs for T2D. Communities' incidence rates were: (1) Margarita, working-class area: 11.3/1000 person-years; (2) Arévalo, agricultural region: 10.1/1000 person-years and; (3) Lista, professional high-income class area: 7.6/1000 person-years.
Conclusion: We found an incidence rate of 9.8/1000 person-years of T2D in the elderly population. The risk of T2D was associated with a lower income and educational level. An increase in BMI may mediate this association. Our results emphasize the necessity of strategies for the prevention of diabetes that includes an approach to SES, educational levels, and other RF among older individuals in Spanish community settings.

1. Introduction

Diabetes Mellitus is considered a public health problem and a large epidemic challenge. Type 2 diabetes (T2D) is the most frequent form of diabetes and it is estimated that by 2045 the number of diabetics will be 629 million worldwide [1]. Type 2 diabetes (T2D) prevalence has increased partially due to the aging of the population as well as the dramatic increase in obesity. In the National Health and Nutrition Examination Surveys (NHANES) from 1999 to 2014, the prevalence of T2D in subjects of ≥65 years old increased from 18.4 to 24.7%, while in the younger population it increased from 8.8 to 11.0% [2].

Funding for the prevention of diabetes requires the knowledge of new cases in the population as well as identification of risk factors (RF) and barriers for adequate care [3]. T2D incidence described in some regions of Spain varied from 8.2 to 19.1/1000 person-years [4–7]. This latter high incidence in the south of Spain was associated with a greater prevalence of obesity.

To our knowledge, there are few studies on the association between socioeconomic status (SES) and incident T2D in the older population taking also into consideration community differences. In the KORA (Cooperative Health Research in the Region of Augs-

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burg) survey, SES was not associated with T2D incidence in the elderly [8]. They suggested that the inverse association between SES and diabetes reported in younger and middle-aged subjects is not necessarily reproducible in the elderly population [9].

The aim of this study was to analyze the association of SES –education, and income- and Risk Factors (RFs) with T2D incidence in a population cohort of elderly individuals living in three Communities of Central Spain during a mean follow-up of 3.35 ± 0.7 years.

2. Material and methods

2.1. Study population

The study was performed in Central Spain in three geographic areas: (1) Las Margaritas, (Getafe district: 14,800 inhabitants) a working-class neighborhood with lower incomes; (2) Lista, (Madrid district: 150,000 inhabitants) a high-income professional class neighborhood and; (3) Arévalo district (9000 inhabitants), an agricultural rural community, medium income. Detailed of the NEDICES study protocol has been published [10].

These areas were selected because there were approximately 2000 elderly inhabitants, computer-based registry medical data, and represented different SES spectrums. We designed the survey to obtain about 2000 people for each area (target population). In fact, the completed census population of Margaritas and the rural area were a little more than 2000 people. In the Lista area with more than 150,000 inhabitants, the Madrid Statistical Services of the Council performed a list of about 2000 people (target population), a proportionate random sample to Spanish senior age and sex structure. Eligibility was restricted to volunteers aged 65 years or older taken from the municipal census. The survey was announced (newspapers, radio, and television), and a letter was sent. In Spain, 99% of the population is covered by the National Health Service (NHS). In Health Centers, each Primary Care Physician (PCP) is in charge of <1500 people [11]. A signed statement of informed consent was a required condition to participate in the survey. Subjects were given a 500 item-screening questionnaire that assessed demographic, health status, as well as lifestyle variables. Data collected was analyzed in 2018. The study was approved by the Ethical Committee of Clinical Investigation of the University Hospital 12 de Octubre, Madrid.

Patients with T2D were identified from the clinical records and confirmed, by their PCP. Participants were considered as T2D if they had a previous diagnosis of T2D, treatment with antidiabetic drugs or insulin, or fasting glucose levels ≥126 mg/dl., according to WHO criteria [12]. In Spain, virtually all drug prescriptions are obtained through the NHS. Type 1 diabetes was ruled out considering the low incidence of 0.3% (95% CI 0.3–0.3%) in adult Spanish subjects [13].

Physical activity (PA) was assessed using an adapted version (4 items) of the Rosow-Breslau physical function measure and classified as: (a) sedentary lifestyle (i.e., only minimal house chores or short walks at home); (b) slight physical activity (i.e., regular house chores, walks independently at home); (c) moderate activity (i.e., regular house chores, walks up to one kilometer per day) and; (d) high activity) i.e., performs heavy housework, walks more than one kilometer or practices any sport regularly) [14]. The level of intensity of the PA based on the number of hours spent was weighted by multiplying the secondary category by 2; slight PA by 1.2; moderate PA by 1.4; and high PA by 1. Next, different cut-off points were calculated based on quartile distribution to classify the subjects as follows: ≤15.6 h (sedentary group), ≤17.6 h (light PA group), ≤19.4 h (high PA group). Weight and height were measured wearing light clothing without shoes; body mass index (BMI) was calculated as kg/m^2. The analysis of blood routine biochemical parameters, by autoanalyzer, was performed after 12 h of fasting.

2.2. Socioeconomic and educational status measurements

Age was analyzed as a continuous variable and by age strata (65–<70; 70–<75; 75–79; and >80 years). Sex was described in percentage and as a dichotomy variable. Education was categorized as formal education in four degrees (taken from municipal census) and as the number of years of schooling (self-reported) years: low: 0–6 years; middle: 7–12 years; high: >12 years, also as a continuous variable. Many clinical (medical disorders, lifestyle habits, cognitive measurements) and anthropometric data were obtained from the participants and their PCP.

Reading ability was assessed by the Word Accentuation Test (WAT) which requires reading aloud several infrequent words written without an accent mark in uppercase letters, as a brief tool to assess reading ability. WAT explores the verbal ability based on 3 irregular words. The better reading is associated with higher intelligence test performance, with an additional 5% of the variation in intelligence score accounted for by reading performance after controlling for age and education. Performance in this test indicates the Spanish reader's level of lexical knowledge which is related to intellectual and educational levels [15].

The participant's occupation was obtained according to the main categories established by the Spanish National Statistics Institute (reported as the occupation that the subject had been employed in for the longest period in their lifespan). These categories were: Class 1: Professionals, managers and skilled professionals; Class 2: Intermediate occupations, semi-skilled professionals and administrative; Class 3: Qualify workers, skilled workers; Class 4: Farmers and; Class5: Unskilled workers [16]. Previous studies of our group have shown that Lista (urban, high educational level and mixed white/blue-collar area) is the suburb with the highest SES in comparison with the Margaritas (urban, low education level and blue-collar area) and the Arevalo suburbs (rural, low education level and blue-collar area). Lista is the area with the highest level of net annual income by the individual (mean 14.214 euros) whereas individuals from Margaritas (mean 7753 euros) and Arevalo (mean 9717 euros) have a lower income status [17].

We used two comorbidity indexes. The adapted Charlson Comorbidity Index (CCI) [18] is a single-number index with possible values ranging from 0 (no comorbidity) to 29 (maximum comorbidity). We also applied the Carey Index, a more recent care morbidity score with adequate validation [19].

2.3. Statistics

Sociodemographic characteristics of patients were described for the complete series with mean, median, and standard deviation values, as well as an interquartile range for quantitative variables. Data were stratified for patients who developed T2D and non-DMs, and their distributions were compared with the Student t-test, Wilcoxon test, or Chi-square statistic according to the nature of the variables. Incidence in our study refers to the number of individuals who developed T2D during three years of follow-up. All the analyses have adjusted for age and sex.

The incidence rate (incidence density) of developing T2D per 1000 person-years was calculated by dividing the number of incident cases with new T2D by the total person-years observed between the two surveys. Age group and sex-stratified the incidence density and target community, and 95% Confidence Interval (95% CI) were added.

RF of developing T2D was calculated using Cox proportional hazard models (CPHM) to examine the risk of diabetes in the different

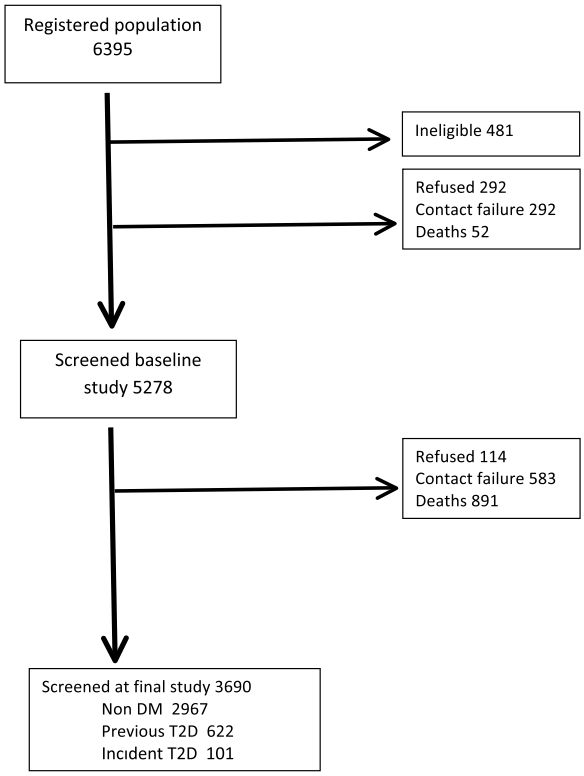

Fig. 1. Flow-chart of the study cohort in Central Spain.

geographical areas and take into account the interval between the first and second surveys for each participant. First, we performed univariate analysis adjusted for age and sex, to create a model that best explains the RF of developing T2D. In the multivariable analysis, we chose the possible RF in the univariate analyses that had a p-value = 0.1. Hazard ratios with 95% confidence intervals were estimated in univariate and multivariable models for the risk factors. All statistical procedures were considered at significance level = 0.05. Statistical analyses were performed with Stata 15 software (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

3. Results

3.1. First survey

Initially, the registered population consisted of 6395 participants but 481 were not possible to contact due to census errors, incorrect address and possible death) and 636 were not included (refused to participate 292, unreachable and 52 confirmed had died) (Fig. 1). The remaining 5278 comprise 4438 non-diabetics (non-DM) and 840 T2D (16.5%) screened at the first evaluation.

3.2. Second survey

After a mean follow-up of 3.35 ± 0.7 years, 3690 participants were screened again, 1588 were not enrolled (refused to participate 114, unreachable 583 and confirmed death 891). There were 2.967 non-DM, 622 previously T2D of the first survey and 101 new incidents T2D.

Of the 6395 invited to participate there were 82.5% positive responders and from 5278 included in the baseline study; follow-up data were available for 3690 (70%) and 1588 (30%) were lost to the second evaluation.

3.3. Characteristics of participants

The main baseline findings are represented in Table 1. Non-diabetic and previously known diabetics had a similar age with incident T2D. There were slightly more females than males in the three groups, without statistical significance. The percentage of current smokers was similar. A greater proportion of non-DM was classified as alcohol drinkers (36.6%) not significantly different from incident T2D and known diabetics (30.4% and 30.5% respectively). BMI was higher in incident T2D compared to non-DM (30.4 ± 5.1 vs. 27.4 ± 4.9, p < 0.001). Previous T2D and incident T2D subjects were more hypertensive (61.2% & 65.4%) compared to non-DM (48.1%, p = 0.036). Deployed PA was similar in both groups of the incident and known diabetics, but higher in non-diabetics.

3.4. T2D incidence in the second survey

The mean incidence of T2D was 9.8 per 1000 person-years (Table 2). T2D incidence in males was 9.3 and in women 10.1 per 1000 person-years. There were no significant differences by stratum of age. There was a slight 5.5 increase in the 75–79 years male group. Comparison of percent of normal BMI, overweight and obese, of patients that developed incident T2D (Table 3) showed that they had a higher mean BMI and percent of obese subjects that continue to be higher at the second survey.

Table 4 includes the incidence of T2D in the studied Communities during the follow-up. Incidence was higher in Margarita (11.36 per 1000 person-year) (urban area with low income), followed by Arevalo (10.14) (rural area, intermediate income) and Lista (7.6) (urban area, high income) (p = 0.005, Fisher's exact test). There were no differences by age stratum in none of the Communities.

3.5. Socioeconomic and educational status impact on T2D incidence

The proportion of illiterates (unable to read or write) comparing incident T2D with known diabetics and Non-diabetics of the first survey was lower in the latter group (18.8%, 19.6%, and 10.6% respectively, P < 0.001), while the number of T2D able to read and write, and with primary and secondary education tended to be higher (Table 1). In Table 5, we report the SES and educational levels of incident T2D compared with non-DM. Lista was the community with more primary, secondary, and higher educational status compared to Arevalo and Margaritas. Regarding years of study, Lista had the highest median value of 11,3 (range 95% IC 6–10) followed by Margarita 4.0 (range 95% IC 0–7) and Arevalo 3.6 (range 95% IC 5–8). As shown in Table 5, Lista was the Community with a lower proportion of development of T2D. Also, T2D incidence was lower considering the occupation, class 1 and 2 in participants subjects of Lista and Arevalo, that had a higher income level respect Margaritas.

WAT study in the second survey was performed in 3068 participants (2967 Non-DM and 101 incident TDM) and showed Lista, had a higher score in both groups (22.6 ± 7,6 and 22.7 ± 6, respectively), compared to Margarita (17.1 ± 7.8 and 16.2 ± 87 respectively) and Arevalo (10.4 ± 6.6 and 9.8 ± 6.1 respectively, p < 0.001).

In Table 6 univariate and multivariable analyses are represented: the event is the risk for developing T2D. BMI, hypertension, occupation, and community T2D incidence were predictor variables in the univariate analyses, and BMI, hypertension and Community T2 incidence, and belonging to a high-income-urban area (Lista) in the multivariable analysis (p < 0.001). A forest plot for adjusted risk in different categories is represented in Fig.2. There were significant differences in the comparison between incidence of T2D comparison between Lista and Margarita (p < 0.01).

Table 1
Baseline subjects characteristics according to Type 2 Diabetes status.

Data	Non-DM (N = 2967)	Incident T2 DM (N = 101)	Known T2 DM (N = 622)	*P*-value
Mean Age (years)	73.18 ± 6.34	73.01 ± 5.38	73.93 ± 6.75	0.76
Sex (females)	1697 (57.2%)	60 (59.4%)	397 (63.8%)	0.01
Mean BMI (kg/m^2)	27.36 ± 4.87	30.42 ± 5.10	30.39 ± 5.09	<0.001
Current smokers (%)	306 (12.0%)	9 (11.4)%	72 (11.6)%	0.65
Alcohol intake- Yes (%)	935 (36.6%)	24 (30.4%)	183 (30.5%)	0.30
Alcohol intake (%)				0.01
0: no	1619 (63.5%)	55 (69.6%)	416 (69.5%)	
1: daily	622 (24.4%)	14 (17.7%)	107 (17.8%)	
2: 3-4 weekly	47 (1.8%)	1 (1.3%)	8 (1.3%)	
3: 1-2 monthly	83 (3.3%)	4 (5.1%)	30 (5.1%)	
4: occasional	179 (7.0%)	5 (6.3%)	38 (6.3%)	
Missing/non-responders	417 (14.1%)	22 (21.8)	23 (3.7%)	
Hypertension (>140/90 mmHg) (%)	1082 (48,1%)	41 (61.2%)	392 (65.4%)	0.015
Physical activity (present)	851 (40.9%)	27 (38.6%)	239 (38.6%)	0.001
Physical activity (%)				0.001
0: sedentarism	553 (23.3%)	22 (31.4%)	198 (32.0%)	
1: light	674 (28.4%)	20 (28.6%)	177 (28.5%)	
2: moderate	549 (23.1%)	15 (21.4%)	134 (21.6%)	
3: high	599 (25.2%)	13 (18.6%)	111 (17.9%)	
Missing/non-responders	592 (19.9%)	31 (30.7%)	3 (0.3%)	
Hypercholesterolemia (>200 mg/dl)	319 (18.5%)	9 (18.85%)	119 (19.1%)	0.04
Educational level				<0.001
1: illiterate	312 (10.6%)	20 (19.8%)	122 (19.6%)	
2: read & write	1210 (41.0%)	39 (38.6%)	240 (38.5%)	
3: primary studies	968 (32.8%)	29 (28.7%)	178 (28.7%)	
4: bachelor and higher studies	459 (15.6%)	13 (12.9%)	82 (13.2%)	
-Mean Carey index	0.68 ± 1.16	0.93 ± 1.26	0.92 ± 1.25	0.08
-Mean Charlson Romano index	0.81 ± 1.08	1.06 ± 1.19	1.07 ± 1.19	0.07

Non-DM: patients without diabetes; Incident T2DM: patients with incident type 2 diabetes; Known T2DM: patients with diabetes since the first survey.
Significant differences found:
-Sex: females Non-DM vs. Known T2DM (p = 0.003).
-BMI :Non-DM vs Known T2DM (p = 0.017); Non-DM vs. incident Type 2 DM (p = 0.001).
- Alcohol intake: Non-DM vs Known T2DM (p = 0.002) y Non-DM vs Known T2DM (p = 0.002); -Hypertension → Non-DM vs Known T2DM (p = 0.036); Non-D M vs. incident Type 2 DM(p = 0.097).
-Physical activity: Non-DM vs Known T2DM (p = 0.027) y Non-DM vs Type 2 D (p = 0.032).
-Educational level → Non-DM vs Known T2DM (p = 0.007) y Non-DM vs incident Type 2 DM (p = 0.006).

Table 2
Incidence of Type 2 Diabetes during the 3 years of follow-up in the total cohort studied according to age.

Stratum (years)	Total				Males				Females			
	No. cases	New T2D	Person-years	Density of incidence (1000 persons-year)	No. cases	New T2D	Person-years	Density of incidence (1000 persons-year)	No. cases	New T2D	Person-years	Density of incidence (1000 persons-year)
65–<70	1093	32	3644.29	8.78 (6.21; 12.41)	486	16	1612.524	9.92 (6.07; 16.19)	607	16	2031.76	7.87 (4.82; 12.85)
70–<75	885	32	2985.14	10.72 (7.58; 15.15)	380	11	1288.96	8.53 (4.72; 15.41)	505	21	1696.18	12.38 (8.07; 18.98)
75–<80	540	22	1813.44	12.13 (7,98; 19.42)	229	11	779.65	14.10 (7.81; 25.47)	311	11	1033.79	10.64 (5.89; 19.21)
>80	550	15	1837.75	8.16 (4.92; 13.53)	216	3	713.28	4.21 (1.36; 13.04)	334	12	1124.47	10.67 (6.06; 18.79)
Total	3068	101	10,280.62	9.82 (8.08; 11.94)	1311	41	4394.42	9.33 (6.8; 12.67)	1757	60	5886.19	10.19 (7.91; 13.12)

New T2D = Incident T2D (CI 95%).

Table 3
BMI percentage of normal, overweight and obese Non-diabetics and incident T2D at the final survey compared to their values at the first survey.

	BMI (kg/m^2) at the initial survey			BMI (kg/m^2) at the final survey		
	Non-DM (n = 2317)	Incident T2D (n = 65)	*P* value	Non-DM (n = 1928)	Incident T2D (n = 61)	*P* value
% Normal (<25)	32.3	13.8		28.9	18.1	
% Overweight (25–30)	43.4	36.9	<0.001*	43.7	37.7	0.004*
% Obese (>30)	24.4	49.2		27.4	44.3	
Mean BMI	27.36 (4.86)	30.42 (5.07)	<0.001**	27.60(4.48)	29.06 (4.47)	0.013**

* Fisher's exact test comparison between participants without diabetes (Non-DM) and type 2 diabetes (T2D).
** Two-sample t-test comparison between controls and type 2 Diabetes. BMI = body mass index.

Table 4
Incidence of Type 2 Diabetes according to age stratum and studied Community.

Stratum (years)	Lista Community				Margarita Comunity				Arévalo Comunity			
	No. cases	New T2D	Person-years	Density of incidence (1000 person-year)	No. cases	New T2D	Person-years	Density of incidence (1000 person-year)	No. cases	New T2D	Person-years	Density of incidence (1000 person-year)
65- <70	377	9	1086.73	8.28 (4.31; 15.92)	357	15	1252.06	11.98 (7.22;19.87)	359	8	1305.49	6.13 (3.07; 12.25)
70- <75	248	4	729.93	5.48 (2.06; 14.60)	283	13	963.74	13.49 (7.83; 23.23)	354	15	1292.47	11.62 (7.00; 19.27)
75- <80	197	4	585.03	6.84 (2.57; 18.22)	173	7	605.37	11.56 (5.51; 24.26)	170	11	623.04	17.66 (9.78; 31.88)
>80	202	6	598.41	10.03 (4.51; 22.31)	173	4	611.61	6.54 (2.46; 17.42)	175	5	627.74	7.96 (3.32; 19.13)
Total	1024	23	3000.10	7.66 (5.09; 11.54)	986	39	3422.78	11.36 (8.30; 15.55)	1058	39	3847.74	10.14 (7.41; 13.87)

New T2D = Incident T2D (CI 95%).

Table 5
Socioeconomic status assessment in the three Communities at the second survey.

Community	Lista		Arevalo		Margaritas		*P value*
	Non-D (n = 1001)	Incident T2D (n = 23)	Non-D (n = 1019)	Incident T2D (n = 39)	Non-D (n = 947)	Incident T2D (n = 39)	
Formal (census-based)							<0.0001
-Illiterates	9 (0.9)	0 (0.0)	113 (11.1)	6 (15.4)	190 (20.1)	14 (35.9)	
-Less than Primary School	386 (39.3)	10 (43.5)	311 (30.5)	13 (33.3)	513 (45.2)	16 (41.0)	
-Primary School	237 (24.11)	7 (30.4)	584 (57.3)	19 (48.7)	147 (15.5)	3 (7.7)	
-Secondary or more	351 (35.7)	6 (26.9)	11 (1.1)	1 (2.6)	97 (10.2)	6 (15.4)	
Years of Study							<0.0001
−0-6 yrs.	251 (30.8)	4 (26.7)	326 (36.3)	13 (44.8)	505 (73.8)	17 (85.0)	
−7-12 yrs.	324 (39.8)	9 (60.0)	566 (63.0)	15 (51.7)	157 (22.9)	3 (15.0)	
-More 12 yrs.	239 (29.4)	2 (13.3)	6 (0.7)	1 (3.5)	22 (3.2)	0 (0.0)	
WAT							
Score	22.6 (7.6)	22.8(6.05)	10.5 (6.7)	9.7(6.16)	17.1(7.9)	16.2(8.7)	<0.001
Occupation*							<0.0001
-Class 1 & 2	61 (7.2)	5 (26.3)	283 (32.8)	6 (18.2)	40 (5.0)	13 (39.4)	
-Class 3 & 4	342 (40.4)	6 (31.6)	325 (37.7)	13 (39.4)	329 (41.0)	10 (30.3)	
-Class 5	444 (52.4)	8 (42.1)	255 (29.5)	14 (42.4)	433 (54.0)	10 (30.3)	
Annual income per cápita ≠ (euros)	14.214		9.717		7.753		

X± (S.D).
* Class 1 Professionals; Class 2 Intermediate occupations: semi-skilled professionals and administrative; Class 3 Qualify workers; Class 4 Farmers and; Class 5: Unskilled workers. WAT test: Word Accentuation Test. ≠ Net annual income by individual (Habits®databse, www.ais-in.com).

4. Discussion

Our study shows for the first time that the mean incidence of T2D in the older population in Central Spain was 9.8/1000 person-years during a mean follow-up of 3 years of Communities representing urban, semi-urban, and rural populations.

The first incidence study of T2D (8.2/1000 person-years) in Spain was performed in the north of Spain (Vizcaya) on 2000 subjects aged >30 years, and in contrast to our study, BMI was not an independent RF during the 10 years of follow-up [4]. Two years later in the east of Spain (Tarragona), an incidence of 9.2/1000 person-years was described in a high-risk population (BMI ≥ 30 kg/m^2, family history of DM, previous history of glycemic alteration)with a mean age of 60 ± 10 years [5]. In the north of Spain (Asturias) a 10.8/1000 person-years incidence of T2D were related to obesity, hypertension, and educational status [6]. A high incidence (19.1/1000 person-years) was reported in the south of Spain (Andalucia) and associated with age, obesity, hypertension, and dyslipidemia, in a follow-up of 5–6 years [7]. This might be associated with a higher proportion of obesity (28.8%). Also might depend on factors, such as methodology and diagnostic criteria, or ethnic variation.

In the Swedish study (T2D identified by the National Drug Register), there was a moderate increase in prevalence, while incidence decreased modestly during the eight years of follow-up [20]. The rise in prevalence could be due to the aging of the population, increased obesity, and lower mortality. We found a slightly higher incidence of 14.1/1000 person-years, in incident T2D in males aged 75–79, and of 13.7 in women aged 80–85, while in the Swedish study, the highest prevalence was in subjects from ≥65 years for both genders. Our data confirm a stable incidence of 9.8/1.000 person-years that compares to the mean average of previous reports of 11.8 in Spain.

Despite our effort to retain participants in the study cohort, 30% were lost. This is in agreement with other studies, that report that in a follow-up survey of older persons, over a third of the population can be lost to death, which in our cohort has been 18% [21].

PA has been reported to be inversely associated with diabetes risk, but in our cohort, we found no association between sedentary and higher levels of physical activity. Vigorous exercise appeared to

Table 6
Univariant and multivariable analysis. Event: risk to develop Type 2 Diabetes.

Variable	Univariate analysis			Multivariable analysis		
	Hazard ratio	CI 95%	*P*-value	Hazard ratio	CI 95%	*P*-value
Age (years)	0.99	0.96–1.02	0.83	1.04	0.99–1.09	0.08
Sex (Female)	1.12	0.75–1.67	0.58	0.86	0.48–1.51	0.59
Overall years of study	0.94	0.89–1.01	0.08			
Years of study						
0–6	1					
7–12	0.71	0.43–1.18	0.19			
>12	0.69	0.21–2.28	0.55			
BMI (kg/m^2)	1.05	1.02–1.07	<0.001	2.88	1.58–4.49	<0.001
Smoking (Yes)	1.11	0.55–2.21	0.77			
Alcohol intake (Yes)	0.91	0.57–1.49	0.73			
Hipercholesterolomia (Yes)	1.25	0.91–1.91	0.32			
Hypertension (Yes)	1.75	1.07–2.86	0.026	1.84	1.00–3.38	0.04
Physical Activity*						
Sedentarism	1					
Light	0.72	0.39–1.31	0.28	1.36	0.64–2.92	0.41
Moderate	0.66	0.34–1.27	0.21	0.99	0.43–2.29	0.98
High	0.56	0.27–1.10	0.09	0.90	0.38–2.13	0.81
Education level						
Illiterate	1					
Read & write	0.63	0.37–1.08	0.09	0.62	0.25–1.54	0.31
Primary studies	0.52	0.29–0.93	0.027	0.50	0.19–1.25	0.14
Bachelor and higher studies	1.04	0.51–2.10	0.923	0.64	0.19–2.14	0.47
Carey Index	1.19	1.01–1.42	0.027	1.12	0.90–1.39	0.29
Romano-Charslon Index	1.23	1.02–1.50	0.031			
N^o of drugs	1.07	0.96–1.20	0.211			
Community						
Lista	1					
Arevalo	2.14	1.25–3.68	0.006	5.56	2.49–10.40	<0.001
Margaritas	1.61	0.99–2.60	0.05	3.10	1.36–7.05	0.007
Occupation						
Class 1 & 2	1					
Class 3 & 4	0.46	0.27–0.81	0.007			
Class 5	0.45	0.26–0.78	0.004			

[a]Sedentary life:(minimal household chores or short walks at home); light (regular household chores, walks independently at home); moderate (performs heavy household chores, walks up to one kilometer per day); high (perform heavy housework, walks more than one kilometer or play any sport regularly).
[b]Class 1: Professional; Class 2: Intermediate occupations: semi-skilled professionals and administrative; Class 3: Qualify workers; Class 4: Farmers and; Class 5: Unskilled workers.

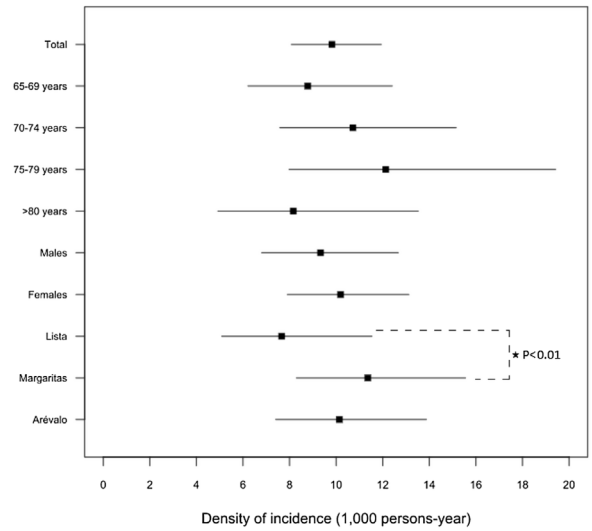

Fig. 2. Forest plots for adjusted risk for age, sex, categories, and differentiated communities with 95% CI for incident T2D.

be more associated with reduced T2D risk than walking, which was recommended to our elderly. Studies are required on the intensity and type of exercise for this purpose [22].

Previous studies showed that the highest risk for incident T2D is found in heavy drinkers (>6 drinks/day) and decreases significantly in moderate drinkers (3–6 drinks/day) [23]. Moderate alcohol intake was not associated with an increase in T2D in our cohort. We found no predictive serum cholesterol value for the development of T2D. Although there has been a reduction of baseline cholesterol probably due to increased screening and pharmacologic treatment by their PCP.

We have not found a higher relative risk for DM between smokers vs. never-smokers. Tobacco has been reported as a potential cause of DM, but no consistent association between tobacco exposures and incident T2D was found in a study with 5931 participants over 10 years [24]. In our study, current smokers did not have a lower rate of diabetes than non-smokers.

Diabetes risk was associated with initial and follow-up high BMI, suggesting that overweight or obesity has a potent influence. It has been reported that the duration of obesity is a primary determinant of T2D risk, by maintaining glucose dysregulation for a long period during which obesity progressively develops [25]. The majority of reports have defined obesity with BMI > 30 kg/m^2, whilst we analyzed all BMI values. In our incident T2D, we found a prevalence of obesity (>30 kg/m^2), of 44% and 49% at the initial and final survey, higher than the 39.8% reported in the Spanish National Health Surveys [26] and the 37.7% in the USA for similar age subjects [2].

Hypertension was registered in 61.2% of incident T2D vs. 48% in the non-DM group. Guidelines do not have consistent Systolic Blood Pressure and Diastolic Blood Pressure goals for adults with DM and hypertension, although there is consensus that risk should be individualized. The hypertension rate in our incident T2D was lower than that reported for a similar population in Spain (75.4%) [27].

An inverse relationship between educational level and the development of DM has been described. For the first time, we have studied this in the older, measuring, years of study, WAT, and the educational level attained. Previous studies in Spain have shown that the WAT, as a "word reading" test is a good estimator of premorbid intelligence and a better predictor of cognitive functioning than sociodemographic variables [15]. WAT showed that Lista had better scores than Margarita and Arevalo, in agreement with Lista being the Community having more subjects with more than 12 years of education. We found an increase for incident T2D, with a lower education level, with a proportion of illiteracy of 19% vs. 10.6% compared with non-DM. Higher educational levels were found in non-DM. Literacy rates for those aged >65 years in Spain, went from 78.8% in 1981 to 95,2.% in 2018, confirming that our T2D rate was in the range [28].

Although studies have claimed an inverse association between SES and incident T2D, it is not clear if this also holds for the elderly. To our knowledge, this is the first study that shows the association of T2D with SES in the elderly. In the KORA S4/F4 Study, in Germany, no association was found during the 7 years follow-up of 887 subjects aged 55–74 years between SES and incident T2D [8]. Adverse risk factors (greater weight, alcohol intake, smokers) could outweigh the effect of SES in this report.

We show for the first time that the incidence of T2D in the elderly varied in the same region. The community with the lowest income (Margaritas) had the greatest incidence of T2D, and those with the highest level (Lista), had a lower incidence. Rural area (Arévalo) - intermediate income- had a medium incidence. Incident T2D, had a lower educational level. The complex mechanisms through which low SES are associated with T2D incidence are not known, and understanding these possible drivers is important for establishing public health policy.

This study has some limitations. The most important is the relatively small number of participants that developed T2D and although a Mediterranean diet was recommended, the diet was not controlled in our cohort and adherence was not strictly follow-up. and therefore these results should be interpreted with caution before making any firm conclusion.

The strengths of our study, include the fact that it comprises urban and rural groups. Life expectancy in Spain is among the highest in the world, more increased in northern regions and this could be a limitation for the extrapolation to the southern regions. According to our NHS, 85% of patients are visited and have two blood glucose determinations each year [11]. Therefore the proportion of undiagnosed cases is low (<10%) in agreement with other surveys in wealthy countries with universal health care systems [29].

5. Conclusions

The results of our study show that there is an independent inverse association between SES and educational level and T2D incidence in the elderly population. BMI was also a major risk factor for T2D. Public interventions in diabetes should necessarily consider improvement in SES and other RF for the prevention of T2D in older people in a Community setting.

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Authors' contributions

FHC, FBP, and MSR made substantial contributions to the conception and design, and they wrote and drafted the article; ACA, SVQ, and JBL revised the manuscript for intellectual content; SVQ and JBL participated in the selection and recruitment of subjects and interpretation; CMA performed the statistical analysis.; FHC, FBP, and MSR approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

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References

[1] International Diabetes Federation, IDF Diabetes Atlas, Available at:, 9th ed., Brussels, Belgium, 2019 https://www.diabetesatlas.org.
[2] H. Caspard, S. Jabbour, N. Hammar, P. Fenici, J. Sheehan, M. Kosiborod, Recent trends in the prevalence of type 2 diabetes and the association with abdominal obesity lead to growing health disparities in the USA: an analysis of the NHANES surveys from 1999 to 2014, Diabetes Obes. Metab. 20 (3) (2018) 667–671, http://dx.doi.org/10.1111/dom.13143.
[3] A. Jones, J. Eyvind Bardeam, P. Baekgaard, et al., Integrated personalized diabetes management goes Europe: a multi-disciplinary approach to innovating type 2 diabetes are in Europe, Prim. Care Diabetes 15 (2021) 360–364, http://dx.doi.org/10.1016/j.pcd.2020.10.008.
[4] J.A. Vazquez, S. Gaztambide, E. Soto-Pedre, 10-year prospective study on the incidence and risk factors for Type 2 Diabetes Mellitus, Med. Clin. (Barc) 115 (2000) 534–539, http://dx.doi.org/10.1016/S0025-7753(00)71616-2.
[5] B. Costa, J.L. Piñol, F. Martin, A. Donado, C. Castell, Significant incidence of type 2 diabetes on high-risk Spanish population. The IGT study, Med. Clin. (Barc) 118 (2002) 287–293, http://dx.doi.org/10.1016/s0025-7753(02)72362-2.
[6] S. Valdes, P. Bota, E. Delgado, F. Alvarez, P. Botas, F.D. Cardorniga, Population-based incidence of Type 2 diabetes in northern Spain, Diabetes Care 30 (2007) 2258–2263, http://dx.doi.org/10.2337/dc06-2461.
[7] F. Soriguer, G. Rojo Martinez, M.C. Almarz, et al., Incidence of type 2 diabetes in southern Spain (Pizarra Study), Eur. J. Clin. Invest. 38 (2008) 126–133, http://dx.doi.org/10.1111/j.1365-2362.2007.01910.x.
[8] B. Kowall, W. Rathmann, K. Strassburger, C. Meisinger, R. Holle, A. Mielck, Socioeconomic status is not associated with type 2 diabetes incidence in an elderly population in Germany: KORA S4/F4 Cohort Study Cohort, J. Epidemiol. Community Health 65 (7) (2011) 606–612, http://dx.doi.org/10.1136/jech.2009.094086.
[9] V. Connolly, N. Unwin, P. Sheriff, R. Bilous, W. Kelly, Diabetes prevalence and socioeconomic status: a population-based study showing increased prevalence of type 2 diabetes in deprived areas, J. Epidemiol. Community Health 54 (2000) 173–177, http://dx.doi.org/10.1136/jech.54.3.173.
[10] J.M. Morales, F.P. Bermejo, J. Benito-León, et al., NEDICES Study Group. Methods and demographic findings of the baseline survey of the NEDICES cohort: a door-to-door survey of neurological disorders in three communities from Central Spain, Public Health 118 (2004) 426–433, http://dx.doi.org/10.1016/j.puhe.2003.10.007.
[11] Actividad Asistencial Atención Primaria. Sistema Nacional de Salud 2007-8. Available at: https://www.mschs.gob.es/estad_Estudios/estadistica/docs/siap/informe_de_actividad_AP_2007-2008.pdf.
[12] Diabetes mellitus. Report of a WHO Study Group. WHO Technical Report Series 727 (1985): p.1–113 ISSN: 0512-305. PMID: 3934850.
[13] J. Reviriego, L.A. Vázquez, A. Goday, M. Cabrera, M.T. García-Margallo, E. Calvo, Prevalence of impaired fasting glucose and type 1 and 2 diabetes mellitus in a large nation wide working population in Spain, Endocrinol. Nutr. 63 (April (4)) (2016) 157–163, http://dx.doi.org/10.1016/j.endonu.2015.12.006.
[14] I. Rosow, N. Breslau, A Guttman health scale for the aged, J. Gerontol. 21 (1966) 556–559, http://dx.doi.org/10.1093/geronj/21.4.556.
[15] T. Del Ser, J.I. González-Montalvo, S. Martínez-Espinosa, C. Delgado-Villapalos, F. Bermejo, Estimation of premorbid intelligence in Spanish people with the Word Accentuation Test and its application to the diagnosis of dementia, Brain Cogn. 33 (April (3)) (1997) 343–356, http://dx.doi.org/10.1006/brcg.1997.0877.
[16] Instituto Nacional de Estadística, Clasificacion Nacional de Ocupaciones 1994(CON-94). Madrid: Instituto Nacional de Estadistica, 1994. Available at: www.madrid.org/iestadis/fijas/clasificaciones/cno94.htm.
[17] I. Contador, F. Bermejo-Pareja, T. Del Ser, J. Benito Leon, Effects of education and word reading on cognitive scores in a community-based sample of Spanish

elders with diverse socioeconomic status, J. Clin. Exp. Neuropsychol. 37 (2015), http://dx.doi.org/10.1080/13803395.2014.989819, 92.101.
[18] P.S. Romano, L.L. Rigs, J.G. Jollis, Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives, J. Clin. Epidemiol. 46 (1993) 1075–1079, http://dx.doi.org/10.1016/0895-4356(93)90103-8.
[19] I.M. Carey, S.M. Shah, T. Harris, S. De Wilde, D.G. Cook, A new simple primary care morbidity score predicted mortality and better explains between practice variations than the Charlson index, J. Clin. Epidemiol. 66 (2013) 436–444, http://dx.doi.org/10.1016/j.jclinepi.2012.10.012.
[20] S.P. Jansson, K. Fall, O. Brus, et al., Prevalence and incidence of diabetes mellitus: a nationwide population-based pharmaco-epidemiological study in Sweden, Diabet. Med. 32 (2015) 1319–1328, http://dx.doi.org/10.1111/dme.12716.
[21] A.H. Mihelic, E.M. Crimmins, Loss to follow-up in a sample of Americans 70 years of age and older: the LSOA 1984-1990, J. Gerontol. 52B (1997) S37–S48, http://dx.doi.org/10.1093/geronb/52b.1.s37.
[22] M.I. Helgren, P.A. Jansson, U. Lindblad, Report from an effort to prevent type 2 diabetes development in primary care, Prim. Care Diabetes 15 (2021) 240–244, http://dx.doi.org/10.1016/j.pcd.2020.08.019.
[23] S.W. Wannamethee, A.G. Shaper, I.J. Perry, K.G. Alberti, Alcohol consumption and the incidence of type 2 diabetes, J. Epidemiol. Community 56 (2002) 542–548, http://dx.doi.org/10.1093/geronb/52b.1.s37.
[24] R.J. Keith, M. Al Rifai, C. Carruba, N. De Jarrett, J.W. McEvoy, A. Bhatnagar, Tobacco use, insulin resistance and risk of T2D: results from the multi-ethnic study of atherosclerosis, PLoS One 11 (2016), eO157592, http://dx.doi.org/10.1371/journal.pone.0157592.
[25] S.G. Wannamethee, A.G. Shaper, Weight change and duration of overweight and obesity in the incidence of Type 2 Diabetes, Diabetes Care 22 (1999) 1266–1272, http://dx.doi.org/10.2337/diacare.22.8.1266.
[26] F.J. Basterra-Gortari, M. Bes-Rastrollo, M. Ruiz-Canela, A. Gea, C. Cayón-Orea, M.A. Martínez-González, Trends of obesity prevalence among Spanish adults with DM, 1987-2012, Med. Clin. (Barc) 152 (5) (2019) 181–184, http://dx.doi.org/10.1016/j.medcli.2018.03.016.
[27] E. Menéndez, E. Delgado, F. Fernández-Vega, et al., Prevalencia, diagnóstico, tratamiento y control de la hipertensión arterial en España. Resultados del estudio Di@bet.es, Rev. Esp. Cardiol. 69 (6) (2016) 572–578, http://dx.doi.org/10.1016/j.rec.2015.11.034.
[28] Unesco Institute for Statistic, Spain Unesco. Available at: http://uis.unesco.org. spain.
[29] A. Weisman, G.S. Fazli, A. Johns, G. Booth, Evolving trends in the epidemiology, risk factors, and prevention of type 2 diabetes: a review, Can. J. Cardiol. 34 (5) (2018) 552–564, http://dx.doi.org/10.1016/j.cjca.2018.03.002.