

Glycemic and weight control in people with type 2 diabetes: A real-world observational study in primary care

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ABSTRACT

Aims: To analyze glycemic and bodyweight control in people with type 2 diabetes mellitus (T2DM), and prescribing patterns in primary care.

Methods: We reviewed the electronic medical records of 5009 randomly selected T2DM patients, from 70 health centers in Spain. We analyzed results by age group and presence/absence of obesity. All data were collected in 2022.

Results: Regarding treatment, 13.2 % of the sample were on lifestyle therapy only, 76.5 % received metformin, 37.6 % SGLT2 inhibitors, 32.2 % DPP-4 inhibitors, 12.2 % GLP-1 agonists, 18.9 % insulin, 6.5 % sulfonylureas, and 1.3 % glitazones. Glycated Hemoglobin (HbA1c) was below 7 % in 57.7 % of patients, and 62.3 % met their individualized HbA1c targets. Overall, 42 % of the population was obese (45.6 % of women vs 39.1 % of men; $p = 0.001$). Obesity rates decreased with age in both sexes. We found no association between obesity and poor glycemic control ($\text{HbA1c} < 7\%$) (43.5 % vs 41.4 %; $p = 0.17$).

Conclusions: In 2022, over 60 % of people with T2DM treated by family doctors in Spain met their individualized glycemic control targets, but only one in three had good glycemic control without obesity. The use of drugs with cardiorenal benefits (particularly SGLT2 inhibitors) is higher than previous published data in our setting.

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1. Introduction

Improving glycemic control in people with type 2 diabetes mellitus (T2DM) can substantially reduce the risk and severity of complications such as blindness, kidney failure, neuropathy, and other microvascular and macrovascular conditions [1–5]. Major clinical guidelines recommend a glycated hemoglobin (HbA1c) target of less than 7.0 % in most people with T2DM, but individualized targets are also recommended according to patient characteristics [6,7]. Population-based studies in primary care have reported high prevalence of poor glycemic control in people with T2DM [8–13], being around 50 % in Spain [14–18]. Nevertheless, there is scarce evidence on the degree of control according to individualized targets [19,20].

Maintaining targets can be challenging because insulin secretion from the beta cells reduces over time, which means HbA1c levels increase in a gradual and linear manner, independently of the treatment prescribed [21,22]. Some studies have shown that T2DM patients with obesity have worse glycemic control, and there is evidence of a direct association between body mass index (BMI) and HbA1c [10,11], however treatment targets are mainly centered on glycemic control rather than comprehensive care, including weight control. Obesity is clearly associated with T2DM, but also with other pathologies [23,24]. In the last few decades, the prevalence of overweight and obesity has increased worldwide in all age groups, including children and adolescents [25].

Although most people with T2DM are overweight or obese, treatment targets are mainly centered on glycemic control rather than comprehensive care, including weight control. SGLT2 inhibitors and GLP-1 agonists, which reduce glucose levels and weight, can contribute to the comprehensive management of this population. However, there is a need for updated research on the joint objective of glycemic and weight control in people with T2DM, and on the real-world effectiveness of new drugs for improving glycemic control in people with T2DM and obesity.

The development of new hypoglycemic drugs such as sodium-glucose co-transporter-2 (SGLT2) inhibitors and glucagon-like peptide-1 (GLP-1) agonists, has increased the therapeutic options for individualizing treatment [4,26]. Although clinical trials have demonstrated the efficacy of these therapies in weight reduction and cardiorenal benefits, there is little evidence on their impact in real-world clinical practice. One study from the USA suggested that many patients continue to have above-target HbA1c levels despite the availability of new therapies, such as SGLT2 inhibitors, GLP-1 agonists, and dipeptidyl peptidase-4 (DPP-4) inhibitors [27].

Since most people with T2DM are overweight or obese, treatment targets should also include weight control. Therefore, there is a need for updated research on the joint objective of glycemic and weight control in people with T2DM, with the incorporation of new drugs. Studies show that too few people with high HbA1c levels are being prescribed new therapies [28–36].

The objectives of this study, conducted in real clinical practice conditions in Spanish primary care centers, were to measure glycemic and weight control in people with T2DM, to evaluate whether prescribing patterns for antidiabetic drugs reflect the recommendations in clinical practice guidelines, and to measure the association between obesity and glycemic control in the context of increased use of new drugs.

2. Methods

We conducted a multicenter cross-sectional study over seven months (January to July 2023) to analyze glycemic and weight control in people with T2DM in Spain. We conducted this study in primary care because family doctors in Spain take the outpatient care for people with T2DM since the 1990s. In 2006, the Spanish Health Ministry launched a national diabetes strategy. Part of this strategy involves training primary care teams (doctors, nurses, and administrative staff) to keep them up to date with the latest research and advances in diabetes diagnosis and

treatment. Family doctors in Spain can prescribe any authorised anti-diabetic drug, except for GLP-1 agonists because the Spanish health system restricts public funding to patients with obesity ($BMI \geq 30 \text{ kg/m}^2$).

3. Sample size calculation and sampling method

We based our sample size on an expected prevalence of poor T2DM control of 50 %, with 3 % precision, a 95 % confidence level, and 15 % expected loss to follow-up. Our calculation gave a minimum sample size of 1197 participants.

Through the Spanish Diabetes Society (SED), we invited primary care centers throughout Spain to join the study. Seventy centers from all Spanish regions agreed to participate. We sampled participants in two stages: first, we randomly selected at least five family doctors from each participating center; then we selected 20 people from each physician's list of T2DM patients, through simple random sampling with a random number table provided by the study coordinators. More investigators than expected agreed to participate in the study (309), providing data for 5262 T2DM patients with entries related to T2DM in their medical records in 2022. All data were uploaded to a shared anonymized electronic registry. After excluding cases with missing values for primary variables, we had a sample of 5009 participants.

4. Glycemic and weight control criteria

Following the recommendations of the American Diabetes Association [4,37,38] and Spanish guidelines [39–41], an HbA1c level below 7 % represented general glycemic control in our study. We defined normal weight as a BMI below 25 kg/m^2 and overweight as a BMI of 25 to less than 30 kg/m^2 . Obesity was divided into different categories: 30 to less than 35 kg/m^2 (class 1); 35 to less than 40 kg/m^2 (class 2), and 40 kg/m^2 or more (class 3). We also recorded individualized glycemic control targets established by the family doctor who usually treats the patient according to the recommendation of ADA guideline 2023. The joint objective of glycemic control without obesity was defined as an HbA1c level below 7 % with a BMI less than 30 kg/m^2 .

5. Explanatory variables

We collected clinical and analytical values recorded in each patient's medical record at the last diabetes related visit in 2022. Adherence to treatment was defined according to the subjective opinion of the family doctor who usually treats the patient, according to three categories: low, medium, and high.

6. Statistical analysis

We performed a descriptive analysis of all variables, presenting absolute and relative frequencies. We used bar graphs to present data on obesity ($BMI \geq 30 \text{ kg/m}^2$) and poor glycemic control ($HbA1c \geq 7 \%$) by sex and age.

To measure the associations of poor glycemic control and obesity with the explanatory variables, we estimated odds ratios (ORs) with their 95 % confidence intervals (CIs) by fitting multivariate logistic models. To select the variables for the model, we used backward elimination based on the Akaike Information Criterion (AIC). We evaluated possible multicollinearity of the variables. To evaluate goodness of fit, we used the likelihood ratio test (LRT) and area under the receiver operating curve (AUC) with its 95 % CI. We used R v.4.3.2 for the statistical analyses.

7. Ethical and legal aspects

This study complies with the requirements of the Declaration of Helsinki for research involving humans. The Ethics Committee of San

Juan de Alicante University Hospital (Alicante, Spain) approved this study (code 22/054).

The processing, storage and use of data complied with Spanish Organic Law 03/2018, of 5 December, on Personal Data and Guarantee of Digital Rights; with Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data; and with all other applicable rules and/or legislation.

8. Results

Table 1 shows the main participant characteristics. Slightly over half of participants were men (56.2%), and the mean age of the sample was 68.7 years (standard deviation [SD] 12.3). Regarding diabetes duration, 22.0% had less than 5 years of diabetes duration, and 28.4% more than 14 years. Nearly six in 10 participants (57.7%) had achieved general glycemic control (HbA1c < 7%), 62.3% had reached their individualized HbA1c target, 39.6% had obesity, and only 32.8% had achieved both; glycemic control without obesity. Table 2 shows that 13.2% of participants were only on lifestyle modifications, and that the most common drugs were metformin (76%), SGLT2 inhibitors (37%), DPP-4 inhibitors (32%), and GLP-1 agonists (12%). Good glycemic control (HbA1c < 7%) was less common in men (53.6% vs 59.6%; $p = 0.02$), people aged below 55 years, people treated with insulin, and people with a longer diabetes duration, but not in people with obesity. The proportion of people with BMI values below 30 kg/m² was greater in men (60.9% vs 54.4%; $p < 0.001$) and in people treated with, DPP-4 inhibitors, sulphonylureas and basal insulin, while most of those treated with GLP1 agonists had obesity. Obesity rates decreased with age and duration of diabetes. Fig. 1 shows the proportion of participants without obesity and with good glycemic control according to sex and age groups. Socio-economic status (SEE) was very low in 5% and high 3.7% of the patients. Good control (HbA1c < 7%) was better in patients with high SEE (60 vs 42.1%; $p = 0.000$). But it was not associated with good weight control, although there was a trend towards a higher proportion of non-obese patients (BMI < 30 kg/m²) among high-versus very low-class patients (53–6 vs 62–5% $p = 0.40$). In the multivariable model, the factors associated with poor glycemic control were older age, lower educational level, lower physical activity level, elevated systolic blood pressure, elevated albumin to creatinine ratio, longer diabetes duration, poor adherence to treatment, use of hypoglycemic drugs, and especially use of a greater number of hypoglycemic drugs (Table 3). There was a U-shaped relationship between age and glycemic control, with the 75–84 age group having the highest attainment rate for glycemic goal (Table 2 & 3).

Table 4 shows the multivariable model with the factors associated with obesity: female sex, lower age, not smoking, not dieting or dieting occasionally, not exercising, high diastolic blood pressure, greater number of comorbidities, diabetes duration shorter than five years, treatments not associated with hypoglycemia, hypertension, no history of cardiovascular events, no history of cancer, and chronic obstructive pulmonary disease (COPD).

9. Discussion

Our results show that people with T2DM treated in primary care in Spain have better glycemic control than previous studies from other countries. Fifty-eight percent had HbA1c < 7% and more than 60% of our participants met their individualized glycemic targets, established by their family doctors in accordance with the ADA 2023 guideline [4]. The International Diabetes Management Practices Study (IDMPS) [42], which included 66,088 people with T2DM, recruited by 6099 doctors in 49 countries in real clinical practice, showed a worsening of glycemic control (HbA1c < 7%) from 36% in 2005 to 30.1% in 2017 ($p < 0.001$). One important source of bias in the IDMPS was the

Table 1
Demographic and disease characteristics.

		n	%
Sex	Male	2815	56.2
Age (years)	< 55	644	12.9
	55–64	1198	23.9
	65–74	1426	28.5
	75–84	1227	24.5
	> 84	51	10.3
Diabetes duration (years)	< 5	1147	22.9
	5–9	1008	20.1
	10–14	1156	23.1
	> 14	1423	28.4
	Missing	275	5.5
Educational level	Illiterate	456	9.1
	Elementary	1252	25.0
	High school	524	10.5
	University	210	4.2
	Missing	2567	51.2
Frequency of exercise	No exercise	1905	38.0
	Weekends only	774	15.5
	Several times a week	1232	24.6
	Missing	1098	21.9
Therapeutic adherence	Low	630	12.6
	Medium	1411	28.2
	High	2359	47.1
	Missing	609	12.2
Socioeconomic status	Low/ Very low	1430	28.6
	Medium	1738	34.7
	High	185	3.7
	Missing	1656	33.1
Smoker	Yes	720	14.4
Hypertension	Yes	3625	72.4
Dyslipidemia	Yes	3610	72.1
Obesity	Yes	1983	39.6
Heart failure	Yes	439	8.8
Atrial fibrillation	Yes	572	11.4
Cardiovascular disease	Yes	1257	26.7
Proliferative retinopathy	Yes	294	5.9
Diabetic kidney disease	Yes	736	14.7
Diabetic neuropathy	Yes	223	4.5
Cancer	Yes	670	13.4
Chronic obstructive pulmonary disease	Yes	693	13.8
Anxiety	Yes	1033	20.6
Depression	Yes	902	18.0
Systolic blood pressure (mmHg)	< 140	3159	63.1
Diastolic blood pressure (mmHg)	< 90	4311	86.1
Glomerular filtration rate (mL/min/1.73 m ²)	≥ 60	3.766	75.2
Albumin-creatinine ratio (mg/g)	< 30	2.484	49.6
HbA1c (%)	< 6.5	1.798	35.9
	6.5–6.9	1094	21.8
	7–7.4	802	16.0
	7.5–7.9	530	10.6
	≥ 8	785	15.7
HbA1c (%)	< 7	2892	57.7
Glycemic control (individualized target)	Good control	2848	62.3
	Poor control	1723	37.7
Body mass index (kg/m ²)	< 25	826	19.1
	25–29.9	1685	38.9
	30–34.9	1151	26.6
	35–39.9	472	10.9
	≥ 40	198	4.6
Glycemic and weight control ^a	Yes	1425	32.8
	No	2916	67.2
	Mean	SD	
Age (years)	68.7	12.3	
HbA1c (%)	7.0	1.2	
BMI (kg/m ²)	29.6	5.4	
Systolic Blood Pressure (mmHg)	133.3	5.7	
Diastolic Blood Pressure (mmHg)	76.3	13.5	

^a Combined outcome: HbA1c < 7% and BMI < 30 kg/m². SD Standard deviation

Table 2

Variable associated with glycemic and weight good control.

	Total		HbA1c < 7 %		p value	BMI < 30 kg/m ²		
	N	%	N	%		N	%	p value
Total	5009	100	2892	57.7		2520	58.1	
Sex								
Male	2815	56.2	1585	56.3	0.02	1490	60.9	< 0.001
Female	2194	43.8	1307	59.6		1030	54.4	
Age group								
< 55 years	644	12.9	344	53.4	< 0.001	276	48.5	< 0.001
55–64 years	1198	23.9	675	56.3		555	53.8	
65–74 years	1426	28.5	830	58.2		722	57.8	
75–84 years	1227	24.5	754	61.5		679	63.1	
> 84 years	514	10.3	289	56.2		288	69.2	
Age group (2 categories)								
Age < 75 years	3268	65.2	1849	56.6	0.02	1553	54.5	< 0.001
Age ≥ 75 years	1741	34.8	1043	59.9		967	64.8	
Educational Level								
Illiterate	456	9.1	234	51.3	< 0.001	227	55.5	0.225
Elementary	1252	25.0	689	55.0		659	57.8	
High school	524	10.5	314	59.9		265	57.9	
University	210	4.2	148	70.5		125	64.4	
Exercise								
No	1905	38.0	1023	53.7	< 0.001	860	50.9	< 0.001
Weekends only	774	15.5	391	50.5		407	57.1	
Several times a week	1232	24.6	837	67.9		777	69.6	
Therapeutic adherence								
Low	630	12.6	199	31.6	< 0.001	288	50.9	< 0.001
Medium	1411	28.2	735	52.1		675	53.2	
High	2359	47.1	1593	67.5		1332	63.6	
Lifestyle modification only	661	13.2	594	89.8	< 0.001	385	58.3	0.25
Metformin	3831	76.5	2177	56.8	0.02	1920	57.6	0.52
SGLT2 inhibitors	1882	37.6	829	44.0	< 0.001	904	54.9	< 0.001
DPP–4 inhibitors	1615	32.2	739	45.8	< 0.001	901	65.8	< 0.001
Basal insulin	948	18.9	248	26.2	< 0.001	499	60.7	0.11
GLP–1 agonists	611	12.2	292	47.8	< 0.001	155	27.9	< 0.001
Sulphonylureas	328	6.5	121	36.9	< 0.001	209	69.0	< 0.001
Rapid-acting insulin	261	5.2	57	21.8	< 0.001	132	58.7	0.42
Glinides	197	3.9	67	34.0	< 0.001	104	61.9	0.54
Pioglitazone	66	1.3	29	43.9	0.04	36	59.0	0.15
Mixed insulin	60	1.2	21	35.0	< 0.001	23	44.2	0.09
Diabetes duration								
< 5 years	1147	22.9	821	71.6	< 0.001	507	51.8	< 0.001
5–9 years	1008	20.1	619	61.4		489	56.9	
10–14 years	1156	23.1	636	55.0		592	59.2	
> 14 years	1423	28.4	657	46.2		812	63.0	
BMI < 30 kg/m²	2520	58.1	1425	56.5	0.17			
BMI ≥ 30 kg/m²	1821	41.9	1067	58.6				
HbA1c < 6.5	1798	35.9				899	58.2	0.458
HbA1c 6.5–6.9	1094	21.8				526	55.5	
HbA1c 7.0–7.4	802	16.0				415	58.9	
HbA1c 7.5–7.9	530	10.6				274	60.0	
HbA1c ≥ 8	785	15.7				406	59.0	

Abbreviations: BMI, body mass index; DPP-4, dipeptidyl peptidase-4; GLP-1, glucagon-like peptide-1; SGLT2, sodium-glucose co-transporter-2.

consecutive recruitment of participants when they visited the doctor. This method could have produced worse results, as poorly controlled patients visit the doctor more often. One recent study conducted in Catalonia (Spain) [43], including 394,266 people with T2DM attended in primary care in 2018, found that 56 % of the population had HbA1c levels below 7 %. The proportion of patients attaining individualized targets was quite similar to that observed in previous studies conducted by our team [19,44]. Finally, the proportion of patients with very poor glycemic control (HbA1c > 9 %) was only 6.6 % in our study, lower than observed in Spain in 2018 (8.4 %) [43], and much lower than observed in the UK in 2015–2016 (17.2 %) [11].

Our study also provides new information on the combined objective of glycemic and weight control, which only one in three of our participants achieved glycemic control without obesity. These findings are similar to those of Boye and colleagues who found that 35.2 % of a retrospective cohort of 44,723 patients in the USA had HbA1c levels below 7 % without obesity [13]. The proportion of people with T2DM and obesity in our study was 39.6 %, which is similar to that of Italy

(39.4 %) and lower than that of other European countries and Australia [10]. Moreover, to the best of our knowledge, this is the first real-life population-based study to find similar levels of glycemic control in people with versus without obesity. The proportion of patients with HbA1c > 7 % was 41 % and we did not observe an association between BMI and HbA1c. In one recent Japanese study, which analyzed the Japan Medical Data Center claims database (JMDC) from 2017 to 2021 and included 106,089 people with T2DM, more than half of people with obesity (54.8–56.5 %) had HbA1c levels of 7 % or higher [41], and there was a direct association between BMI and HbA1c level. Boye et al. [44], in a retrospective cohort study using insurance claims data showed that, compared to individuals of normal weight, those classified as obese class I or obese class II were 24 % more likely to have HbA1c ≥ 7 % (OR=1.24; 95 %CI 1.14–1.35). In this study, there was a high use of sulphonylureas (19.8 %), low use of metformin (42.1 %), and very low use of SGLT2 inhibitors (2.9 %) and GLP-1 agonists (5 %). This relationship between the presence of obesity and a higher proportion of patients with poor glycemic control has also been observed in other studies (43,11),

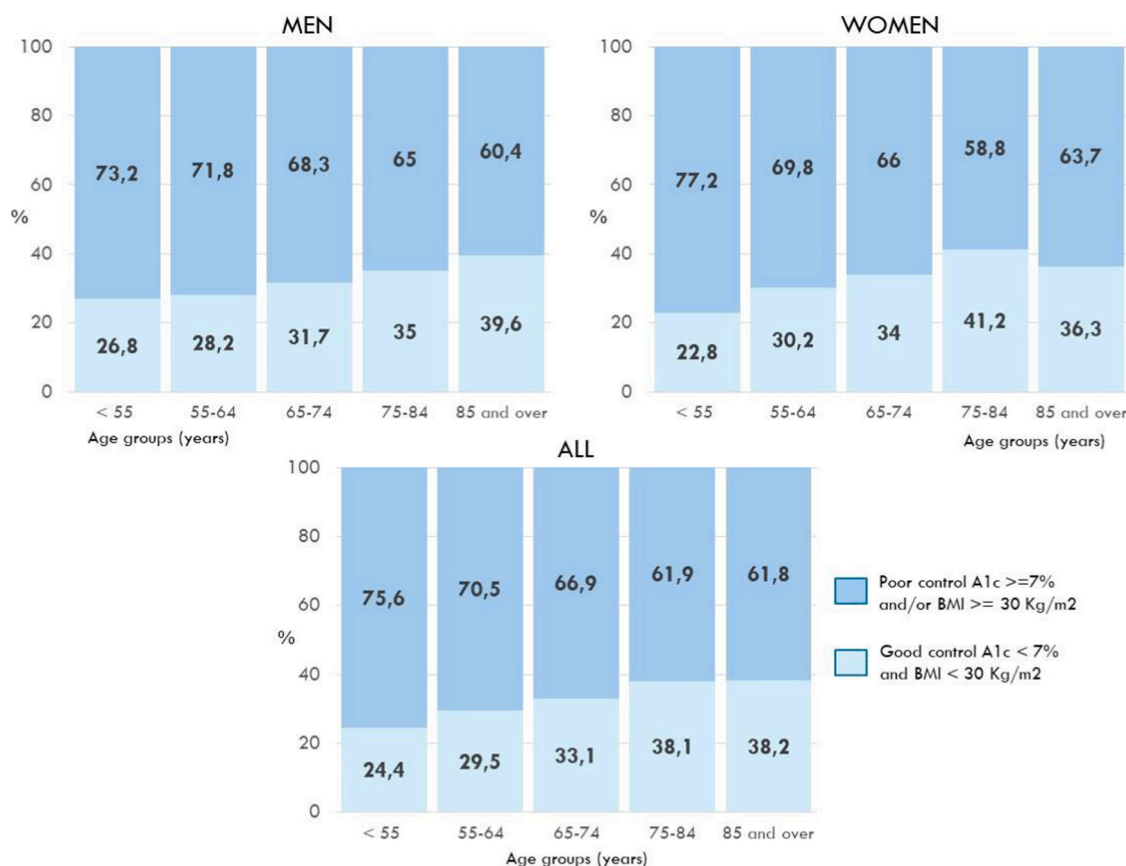


Fig. 1. Proportion of people with type 2 diabetes without obesity and with good glycemic control, according to sex and age group.

and in all of them the use of SGLT2 inhibitors and GLP-1 agonists was very low. In relation to pharmacological treatment, we found a higher proportion of people treated with SGLT2 inhibitors (37.6 %) and GLP-1 agonists (12.2 %) in comparison to other population-based studies in primary care. Interestingly, after adjusting for age, diabetes duration, and other variables, we found that use of drugs with risk of hypoglycemia (sulfonylureas, glinides, insulin) was independently associated with a two-fold increased risk of poor control (OR 2.27, 95 % CI 1.92–2.69; $p < 0.001$) (Table 3). In this context, our results suggest that greater use of SGLT2 inhibitors and GLP-1 agonists is one of the potential factors that have contributed to the improvement of glycemic control, especially in people with obesity. One recent study [43], including 75,739 T2DM patients on metformin who began a second therapy (sulfonylureas, DPP-4 inhibitors, or SGLT2 inhibitors) owing to poor glycemic control, concluded that SGLT2 inhibitors were more effective than the other two medications for reducing HbA1c. Moreover, there is large published evidence that delays in treatment intensification and low adherence to treatment promotes to poor glycemic control, and these factors are often motivated by fear of hypoglycemic episodes, weight gain, and injections [45]. The prescribing patterns of family doctors in Spain adhere quite closely to current guidelines [5,46] as reflected in a lower use of sulfonylureas and much higher use of SGLT2 inhibitors and GLP-1 agonists, compared to other countries [10,11,31]. Montvida and colleagues [8] included people with T2DM who were starting any antidiabetic drug ($n = 1023,340$) prescribed by around 35,000 doctors (75 % primary care physicians) in the USA. They also analyzed the data of people who started a second-line antidiabetic after metformin ($n = 35,482$) between 2005 and 2016, finding a reduction in the use of sulfonylureas as a first therapeutic option (20 % vs 8 %) and a second therapeutic option (60 % vs 46 %). In 2016, fewer than 2 % of the population received SGLT2 inhibitors as first-line treatment and 7 % as second-line treatment. Similar proportions of people were receiving

GLP-1 agonists. The six-year difference (2016 and 2022) may partly explain these differences in comparison to our study. In addition, the cost for patients of new drugs is much higher in the USA, while in Spain almost the full cost is covered by the National Healthcare System. Thus, the better glycemic and weight control observed in Spain compared with other countries may be related to the better adherence of family doctors to clinical practice guidelines, but also to the near complete funding of antidiabetic treatments by the National Health Service, specifically SGLT2 inhibitors and GLP-1 receptor agonists. It is noteworthy that 16 % of our participants had HbA1c levels between 7 % and 7.5 %, which means that with a small effort to counter therapeutic inertia—which is common in people with borderline values—we could achieve a glycemic control rate of more than 75 %.

Other factors that may have influenced the good results observed are the good indicators of the Spanish national health system [47,48], and the important activity of continuing education in diabetes among family doctors. The Spanish Diabetes Society (www.sediabetes.org) has a special interest working group for primary care professionals. In addition, there is also a national scientific foundation for diabetes in primary care, the Primary Care Diabetes Study Groups Network (www.redgdps.org), and other three primary care scientific societies that have working groups on diabetes: the Spanish Society of Family and Community Medicine (www.semefyc.es), the Spanish Society of Primary Care Physicians (www.semergen.es), and the Spanish Society of General and Family Doctors (www.semge.es).

10. Limitations and possible biases

One limitation common to all studies conducted in real clinical practice is the risk of missing data. However, electronic medical records facilitate data recording because much of the process is automated; for example, laboratory values are received directly from the laboratory

Table 3
Multivariable logistic model. Variables associated with poor glycemic control (HbA1c ≥ 7 %>).

		OR	95 % CI	p value
Age group (years)	> 84	1.65	(1.29–2.11)	0.00
	75–84	1	—	—
	65–74	1.15	(0.96–1.38)	0.11
	55–64	1.23	(1.01–1.50)	0.03
	< 55	1.57	(1.23–2.00)	0.00
Educational level	University education	1	—	—
	Secondary education	1.56	(1.05–2.31)	0.02
	Primary education	1.77	(1.23–2.54)	0.00
	No schooling	1.76	(1.17–2.64)	0.00
	Missing	1.77	(1.24–2.51)	0.00
Physical activity	Various times a week	1	—	—
	Only weekends	1.41	(1.14–1.75)	0.00
	None	1.17	(0.97–1.40)	0.08
	Missing	1.18	(0.96–1.46)	0.11
Systolic blood pressure (mmHg)	Normal (< 140)	1	—	—
	Elevated (≥ 140)	1.21	(1.05–1.39)	0.00
	Missing	0.92	(0.67–1.26)	0.60
Albumin to creatinine ratio (mg/g)	< 30	1	—	—
	≥ 30	1.22	(1.02–1.47)	0.02
	Missing	1.12	(0.97–1.30)	0.10
Diabetes duration (years)	< 5	1	—	—
	5–9	1.23	(1.00–1.51)	0.04
	10–14	1.34	(1.09–1.65)	0.00
	> 14	1.53	(1.2–1.89)	0.00
	Missing	1.26	(0.92–1.72)	0.14
Adherence to treatment	High	1	—	—
	Moderate	1.83	(1.57–2.14)	< 0.001
	Low	3.98	(3.18–4.97)	< 0.001
	Missing	1.43	(1.14–1.79)	0.00
Drugs with risk of hypoglycemia (sulfonylureas, glinides, insulin)	No	1	—	—
	Yes	2.26	(1.91–2.68)	< 0.001
	Missing	1.06	(0.78–1.44)	0.67
Number of antidiabetic drugs	0	1	—	—
	1	2.52	(1.68–3.78)	< 0.001
	2	5.80	(3.87–8.69)	< 0.001
	3	10.86	(7.13–16.5)	< 0.001
	4 or more	12.33	(7.60–19.9)	< 0.001

n = 5009, n with poor glycemic control = 2117; Chi-square LRT = 129 (p < 0.001); AUC = 0.78 (95 % CI 0.771–0.796). Abbreviations: AUC, area under the receiver operating curve; CI, confidence interval; LRT, likelihood ratio test; OR, odds ratio.

that performs the analysis. In addition, we controlled for the possibility of losses when calculating the sample size.

There may have been some degree of selection bias, as the physicians in centers that agreed to participate may be more interested in the treatment of T2DM. However, within each center, we selected at least five physicians at random, and the large number of participating physicians (309) probably reduced the risk of selection bias. Furthermore, unlike in other studies, we selected a random sample of people from the patient list of each participating family doctor, rather than including consecutive patients. We consider this random selection one of the strengths of the study, as we included all kinds of patients, with varying levels diabetes severity, glycemic control, and primary care attendance. This ensured our results were representative. The cross-sectional nature of the study prevented a direct review of the time trend in metabolic control, and drug use, and the association of changes over time. However, we describe in a cross-sectional, population-based study in primary

Table 4
Multivariable logistic model for presence of obesity (BMI ≥ 30 kg/m²).

		OR	95 % CI	p value
Sex	Male	1	—	—
	Female	1.24	(1.08–1.43)	0.00
Age (years)	> 84	1	—	—
	75–84	1.53	(1.18–1.98)	0.00
	65–74	2.27	(1.75–2.94)	< 0.001
	55–64	2.79	(2.12–3.67)	< 0.001
	< 55	4.18	(3.04–5.74)	< 0.001
Smoking	No	1	—	—
	Ex-smoker	1.02	(0.85–1.23)	0.80
	Smoker	0.55	(0.45–0.68)	< 0.001
	Missing	0.92	(0.72–1.17)	0.48
Dieting	Adequate	1	—	—
	Occasional	1.56	(1.17–2.07)	0.00
	None	1.51	(1.14–2.01)	0.00
	Missing	1.30	(0.88–1.92)	0.18
Exercise	Various times/week	1	—	—
	Only weekends	1.12	(0.79–1.58)	0.53
	None	1.54	(1.18–2.01)	0.00
	Missing	1.15	(0.77–1.70)	0.49
Diastolic blood pressure	< 90 mmHg	1	—	—
	≥ 90 mmHg	1.65	(1.31–2.06)	< 0.001
	Missing	1.71	(0.93–3.15)	0.09
No. of comorbidities	None	1	—	—
	1–3	5.81	(2.03–16.66)	0.00
	4–6	13.62	(4.73–39.20)	< 0.001
	> 6	20.83	(7.17–60.56)	< 0.001
	Missing	10.13	(3.47–29.54)	< 0.001
Diabetes duration	> 14 years	1	—	—
	10–14-years	1.06	(0.88–1.27)	0.55
	5–9-years	1.14	(0.93–1.39)	0.19
	< 5 years	1.44	(1.17–1.76)	< 0.001
	Missing	1.31	(0.95–1.79)	0.09
General adherence	High	1	—	—
	Moderate	1.29	(1.10–1.50)	0.00
	Low	1.19	(0.96–1.49)	0.10
	Missing	1.35	(1.06–1.73)	0.01
Drugs with risk of hypoglycemia (sulfonylureas, glinides, insulin)	No	1	—	—
	Yes	1	—	—
	Missing	1.26	(1.08–1.47)	0.00
	Yes	1.43	(1.02–2.02)	0.03
	Yes	1.41	(1.19–1.67)	< 0.001
	No	1	—	—
	Missing	1.01	(0.47–2.19)	0.97
Cardiovascular event	Yes	1	—	—
	No	1.44	(1.22–1.69)	< 0.001
	Missing	1.63	(1.16–2.30)	0.00
Cancer	Yes	1	—	—
	No	1.38	(1.13–1.68)	0.00
	Missing	0.95	(0.62–1.45)	0.81
COPD	No	1	—	—
	Yes	1.26	(1.04–1.52)	0.02
	Missing	1.51	(1.02–2.24)	0.04

n = 4346; number with obesity = 1821; Chi-square LRT = 542.2 (p < 0.001); AUC = 0.701 (95 % CI 0.686–0.717). Abbreviations: AUC, area under the receiver operating curve; CI, confidence interval; COPD, chronic obstructive pulmonary disease; LRT, likelihood ratio test; OR, odds ratio

care, the degree of recent glycaemic control which includes a high use of SGLT2 inhibitors, and GLP-1 agonists according to current guideline recommendations in comparison to previous studies where the use of these drugs is lower.

11. Conclusions

People with T2DM treated by primary care physicians in Spain had better glycemic control and better weight control compared with other population studies in several countries. Despite of this, only one in three

T2DM patients had good glycemic control without obesity.

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