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Cooking for control: assessing the relationship between culinary knowledge and home cooking habits in the type 1 diabetes population

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ABSTRACT

In this study we analyzed culinary knowledge, skills, and habits among Spanish adults with type 1 diabetes mellitus, exploring their relationship with sociodemographic variables and glycemic control. A descriptive cross-sectional study was conducted with 287 participants recruited via social media and diabetes associations. Data were collected using a culturally adapted questionnaire assessing culinary competencies, habits, and clinical variables. Participants demonstrated high self-perceived culinary competence, particularly in cooking vegetables and proteins. While family remains the primary source of initial learning (79.8%), digital platforms have emerged as the leading resource for recipes (48.1%). Significant sex and age differences were observed: both women and adults over 30 reported higher home-cooking frequencies, women also reported more frequent use of healthy techniques, and younger adults relied more heavily on unhealthy techniques. Notably, better glycemic control (HbA1c $< 7\%$) was significantly associated with higher culinary knowledge scores and lower use of unhealthy cooking techniques and additives. Culinary self-efficacy is a key driver for healthier lifestyle choices in type 1 diabetes mellitus management. These findings highlight the need to integrate practical culinary training and digital literacy into formal diabetes education to improve long-term metabolic outcomes.

Introduction

Type 1 diabetes mellitus (T1DM) is a chronic metabolic disease characterized by uncontrolled elevated blood glucose levels. T1DM is initiated by an autoimmune attack that targets pancreatic β-cells, which are responsible for insulin production, the key hormone regulating glucose homeostasis [1]. The destruction of these β-cells leads to an absolute insulin deficiency, requiring lifelong exogenous insulin administration.

It is estimated that approximately 8.4 million individuals worldwide are living with T1DM [2,3]. The most frequent age at diagnosis of T1DM is during childhood and adolescence (<20 y) [4]; however, in recent years, the age of T1DM onset has been shifting to adulthood [5]. The prevalence of T1DM has also increased over time. As an example, in the United States of America, the prevalence among individuals younger than 19 y rose from 1.48 cases per 1000 youths in 2001 to 2.15 cases per 1000 in 2017 [6]. However, the global distribution of T1DM is highly heterogeneous. Finland continues to exhibit one of the highest incidence rates worldwide [7], whereas Asian countries such as China or Japan report substantially lower rates [8]. The underlying causes of T1DM remain unclear, and currently there is no curative treatment nor effective intervention that prevents its onset.

Abbreviations: (BMJ), British Medical Journal; (DPP-4), Dipeptidyl peptidase-4 inhibitors; (EUR), Euro(s); (GLP-1), Glucagon-like peptide-1 receptor agonists; (HbA1c), Glycated hemoglobin/hemoglobin A1c; (IQR), Interquartile range; (JAMA), Journal of the American Medical Association; (SMI), Minimum Interprofessional Wage; (SGLT2), Sodium-glucose cotransporter-2 inhibitors; (SD), Standard deviation; (TIR), Time in range; (T1DM), Type 1 diabetes mellitus; (WHO), World Health Organization

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Currently, two key parameters are used to assess the degree of glycemic control in individuals with type 1 diabetes: glycated hemoglobin (HbA1c) and time in range (TIR). HbA1c reflects average glycemic levels over the preceding 2 to 3 mo and is expressed as a percentage. An HbA1c value <7.0% is generally considered indicative of excellent glycemic control, 7.0% to 8.0% as moderate control, and >8% as poor control [9]. TIR represents the proportion of time that glucose levels remain within the target range of 70 to 180 mg/dL. A TIR >70% is widely accepted as a marker of good glycemic control [10].

Patients with poor glycemic control may experience significant impairment in quality of life due to both direct and indirect complications. Direct complications include hypoglycaemia, hyperglycemia, and diabetic ketoacidosis, which can lead to life-threatening episodes requiring immediate management. Indirect complications, largely driven by endothelial dysfunction, include diabetic retinopathy, neuropathy, myocardial infarction, and arterial hypertension, among others [11]. Importantly, diabetes also exerts a considerable burden on mental health, with affected individuals frequently experiencing depression, anxiety, and stress [11].

The treatment of T1DM is essential to prevent the development of complications and is based on continuous glucose monitoring, insulin administration (by injections or insulin pump), regular physical activity, mental health care, and appropriate nutritional management, among other components [12]. Appropriate nutritional management is one of the cornerstones of successful treatment; however, it represents a significant challenge for individuals living with T1DM. Several barriers have been identified, including difficulty in adopting new dietary habits, poor adherence to nutritional recommendations, limited access to structured diabetes education, challenges associated with carbohydrate counting, emotional factors, and social pressure [13]. Furthermore, 61% of individuals with T1DM report avoiding foods such as pizza, fruit juices, or desserts due to the perceived difficulty in managing postprandial glycemic associated with their consumption [14].

Hofer et al. [15] demonstrated that individuals with greater knowledge of diabetes and nutrition achieved, on average, a 0.5% reduction in HbA1c and a 9% lower TIR compared with individuals with T1DM who had lower levels of knowledge. Optimal nutrition in individuals with T1DM requires not only evidence-based dietary recommendations but also adequate culinary skills and the development of sustainable eating habits that support appropriate and long-term metabolic management.

On one hand, culinary skills, defined as the physical and mechanical abilities required for food preparation, play a pivotal role in shaping dietary behaviors [16]. However, cooking encompasses far more than technical proficiency alone; it involves the integration of culinary techniques, the effective use of kitchen equipment, informed food selection, strategic menu planning, and the efficient management of ingredients, including the incorporation of leftovers. Collectively, these competencies contribute to the adoption of healthier and more sustainable dietary patterns, highlighting the critical importance of culinary education as a determinant of improved nutritional outcomes [17].

On the other hand, dietary habits exert a substantial influence on overall health. Nutrition, food selection, and eating behaviors are intrinsically linked to culinary practices, collectively shaping health outcomes and overall well-being. Historically, healthy dietary practices were defined primarily through nutrient composition; however, this concept has evolved considerably over recent decades. From a contemporary health perspective, cooking at home has been associated with higher overall diet quality, a greater presence of unprocessed or minimally processed foods, and lower intake of ultra-processed foods [18,19]. However, cooking at home does not in itself guarantee a healthy diet. Rather, it may constitute a context in which individuals exert greater control over ingredients, culinary techniques, and the degree of processing of the foods consumed, especially in relation to industrial products perceived by some consumers as less transparent or as having poorer nutritional profiles [20].

In the context of this study, "healthy cooking methods" are explicitly defined as dietary practices that preserve the nutritional integrity of foods, minimize the addition of saturated fats and sugars, and favor techniques such as baking, steaming, or grilling over traditional deep-frying [21,22]. The preventive function attributed to home cooking is also articulated with its role as a space for cultural transmission. In the Spanish context, many household culinary practices are related to values associated with the Mediterranean diet, recognized both for its nutritional interest and for its cultural and heritage dimensions [23–25]. Certain traditional preparations may function as references of culinary continuity, family identity, and cultural belonging, although their forms of preparation may adapt to current conditions of time, food availability, culinary technology, and household organization. The Mediterranean diet incorporates, in addition to specific foods, values of commensality, seasonality, and social connection that reinforce its cultural and health relevance [23–26].

The tension between the preventive, cultural, and symbolic value of home cooking and the contemporary conditions that hinder its practice allows culinary and nutrition education to be situated as an area of growing interest. If cooking at home has been related to greater control over ingredients, lower dependence on ultra-processed foods, and the continuity of food knowledge linked to traditional patterns, the possible weakening of these competencies may be interpreted not only as an individual issue but also as a matter related to public health, food autonomy, and social equity.

In this sense, culinary and nutrition education has been proposed as a strategy to strengthen food autonomy, public health, and the transmission of practical competencies. Recent literature indicates that culinary skills constitute a relevant component of food autonomy and that low self-perceived cooking competence is associated with higher consumption of ultra-processed foods, particularly among young people [27]. Likewise, culinary education and practical cooking-teaching strategies have been proposed as promising tools for health promotion, the improvement of food competencies, and future prevention [28].

Taken together, we hypothesize that higher self-perceived culinary competence and the adoption of healthier home-cooking practices act as positive contributors to diabetes self-management, being significantly associated with optimal metabolic control (HbA1c < 7%) in individuals with T1DM. Conversely, lower culinary knowledge and the frequent use of unfavorable cooking techniques or additives are expected to be linked with poorer glycemic control.

The purpose of this study was to analyze the culinary knowledge, skills, and habits of Spanish individuals with type 1 diabetes, examining their relationship with sociodemographic variables and their potential impact on diabetes management.

Methods

Type of study

This research employed descriptive cross-sectional study design. The study focused on analyzing the culinary competencies and habits of the Spanish population with T1DM.

Sample size calculation and sampling

To determine the required sample size for the population with type 1 diabetes, the study utilized data from the Spanish Diabetes Society [29,30], which estimates that 90 000 individuals suffer from this condition in Spain. Considering a 95% confidence level, a 7% margin of error, and maximum variability ($P = q = 0.5$), the minimum required sample size was calculated to be 196 participants. The sampling method employed was non-probabilistic snowball sampling [31], with the survey disseminated through the researchers' personal social media accounts, the official channels of the Diabetes Cure Research Association—including its website, social media, and networks of associates—and the collaboration of various diabetes associations throughout the Spanish territory. Data collection took place from June 2025 to January 2026.

Inclusion and exclusion criteria

The selection of participants for this study followed specific criteria tailored to the T1DM population:

Inclusion criteria:

- Individuals aged 18 y or older.
- Spanish nationality and residency in Spain.
- Diagnosis of type 1 diabetes for more than 1 y.

Exclusion criteria:

- Participants in temporary situations that disrupt their usual diet at the time of the survey, such as hospitalization or incarceration.
- Individuals with physical or mental limitations that prevent them from cooking.
- Presence of any disease other than diabetes that affects their dietary habits.
- Provision of untruthful data regarding their diabetic condition.

Ethical requirements

The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki [32] and was approved by the Research Ethics Committee of Universidad Católica de Valencia (approval number UCV/2024-2025/144, June 4, 2025). Prior to completing the questionnaire, participants were required to provide informed consent to take part in the study and to allow the use of their data for research purposes. If a participant did not grant this consent, the questionnaire was automatically terminated, and no information was recorded.

Instrument

Data on the population's culinary knowledge were collected using a questionnaire that was translated and culturally adapted by researchers from the University of Blanquerna [33]. This instrument is based on the original English version, which was developed and validated in Ontario [34]. Following the same approach applied by Sandri in a study of a healthy Spanish population [35], seven additional qualitative questions were incorporated. These questions, designed with input from subject-matter experts, aimed to obtain further information on culinary practices and the type of cuisine followed by the participants. Finally, socio-demographic data on the population were collected.

Measurements

Sociodemographic variables

The variables included in the analysis were: participants' sex (recorded in binary form as male or female), age (categorized into young [18−30 y] or adults [>30 y]), educational level (classified as basic education [no formal studies, primary or secondary education, vocational training, or baccalaureate] and higher education [university degree, Master's, or PhD]), work situation (distinguishing between employed, unemployed, student, retired and do not work), and finally income level. Income level was categorized into three groups: Low income (≤2200 EUR/mo), medium−high income (>2200 EUR/mo), and not specified. This threshold was defined based on socio-economic standards relevant to Spain. According to Royal Decree 231/2020 of 4 February, the Minimum Individual Wage (Salario Mínimo Interprofesional, SMI) for 2020 was set at 950 EUR/mo in 14 payments, equivalent to approximately 1108 EUR/mo when divided into 12 payments. Considering Spain's economic structure and the assumption that a household requires at least double the individual SMI to maintain an adequate living standard, we established 2200 EUR/mo as the reference point for distinguishing low versus medium−high household income levels in this study.

Health and diabetes-related variables

The questionnaire included a specialized section for participants with diabetes to gather clinical data relevant to their condition. The following variables were collected:

- *Disease duration*: Measured by asking participants the specific year of their diagnosis. This allowed for the calculation of total years living with the condition.
- *Therapeutic management*: Participants selected their current treatment from a comprehensive list. Options included oral medications (such as metformin, GLP-1 agonists, SGLT2 inhibitors, or DPP-4 inhibitors), insulin therapy (via multiple daily injections or continuous subcutaneous insulin infusion/pumps), or a combination of both pharmacological agents and insulin.
- *Glycemic monitoring methods*: The technology used for daily glucose tracking was identified by choosing between traditional blood glucose meters (capillary testing), standalone continuous or flash glucose sensors, or glucose sensors integrated with an insulin pump.
- *Metabolic control (HbA1c):* Participants provided their most recent glycated hemoglobin (HbA1c) value, representing their average blood sugar levels over the previous 3 mo. Participants with a value <7.0% were categorized as having good glycemic control, while those with a value ≥7.0% were considered to have poor glycemic control [9,36]. Finally, a TIR greater than 70% is considered an indicator of good control [10].

Culinary habits

Seven questions investigate the cooking habits of the population; the question on where respondents consult cooking recipes is qualitative, while the others have been categorized according to the criteria indicated in Table 1. The first three questions represent cooking habits that have a positive impact on health, while questions 4, 5, and 7 describe habits with a negative impact.

To ensure a precise quantitative evaluation, culinary habits were operationalized into specific behavioral domains based on their impact on dietary quality. "Healthy cooking techniques" were defined as methods that minimize added fats (e.g., grilling, steaming, baking), whereas "unhealthy cooking techniques" referred to methods involving high-fat incorporation or deep-frying. "Caloric

Table 1
Categorization of culinary habit variables in patients with type I diabetes

Variables	Categorization
1. Home cooking frequency	
Normally, I do not cook	0
1–2 times a week	1
3–4 times a week	2
Every day or almost every day	3
2. Frequency of use of household appliances healthy cooking	Liker scale 1–5 (1 = never, 5 = always)
3. Frequency of use of healthy cooking techniques	Liker scale 1–5 (1 = never, 5 = always)
4. Frequency of use of unhealthy cooking techniques	Liker scale 1–5 (1 = never, 5 = always)
5. Frequency added unhealthy condiments and sauces	Liker scale 1–5 (1 = never, 5 = always)
6. Channels for consulting recipes	Qualitative
7. Frequency of convenience food consumption	
None	1
Between 1 and 3 times	2
Between 4 and 5 times	3
More than 5 times	4
I do not know	0

additives and sauces" included the frequent addition of items such as mayonnaise, ketchup, butter, or cream during or after food preparation. Finally, "convenience food consumption" quantified the frequency of utilizing ultra-processed or externally preprepared meals rather than cooking from scratch.

Culinary knowledge

All items (n = 18) assessing culinary knowledge were presented using a Likert-type scale ranging from 1 (not very confident) to 5 (very confident), allowing participants to indicate their level of confidence in relation to specific culinary skills. The total score ranged from 18 to 90 points.

Statistical analyses

Following data collection, questionnaire responses were entered into a Microsoft Excel database and systematically reviewed to identify and correct potential errors or inconsistencies, with particular attention to data entry issues and outliers. Certain variables were subsequently derived or categorized based on others. To enhance data reliability, extreme body mass index values (below 14 and above 40) were excluded from the analysis.

After data cleaning and variable definition, the dataset was imported into Jamovi software (version 2.3.28.0) [37] for statistical analysis. The normality of the sample distribution was assessed using the Shapiro–Wilk test, which revealed that none of the variables followed a normal distribution. This finding was further supported by visual inspection of Q–Q plots [38].

As a result, non-parametric statistical methods were applied. The Chi-square test was used for the analysis of categorical variables, while the Mann–Whitney U test was employed for comparisons involving independent ordinal or continuous variables. Statistical significance was established at a P value of 0.05. Categorical variables are presented as frequencies and percentages, whereas continuous variables are reported using both mean and standard deviation (SD), as well as median and interquartile range (IQR).

Finally, associations between culinary habits and culinary knowledge variables were examined using Spearman correlation coefficient. Statistically significant correlations were identified and reported accordingly.

Results

Socio-demographic characteristics

A total of 287 participants were included in the analysis. Table 2 describes the socio-demographic characteristics of the sample. The sample was predominantly female, with 220 women (76.7%) and 67 men (23.3%). The mean age of the participants was 40.1 ± 14.0 y, with a median age of 37 y (IQR: 18.9). Ages ranged from 18 to 74 y. Most participants were adults older than 30 y (68.3%), while 31.7% were classified as young adults aged 18 to 30 y.

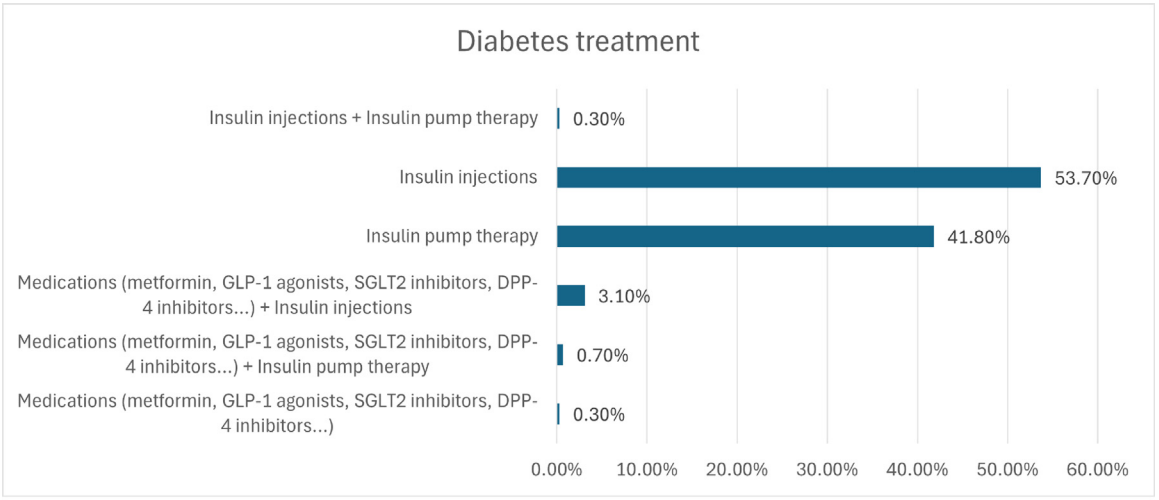
Regarding educational level, 55.7% of participants reported having higher education, whereas 44.3% had basic education. Almost half of the sample reported a low-income level (48.1%), followed by a medium–high income level (38.7%); 13.2% of participants did not know or preferred not to answer this question.

In terms of employment status, most participants were employed (70.0%). The remaining participants were students (11.8%), unemployed (8.0%), retired (7.0%), or not engaged in work activities (3.1%).

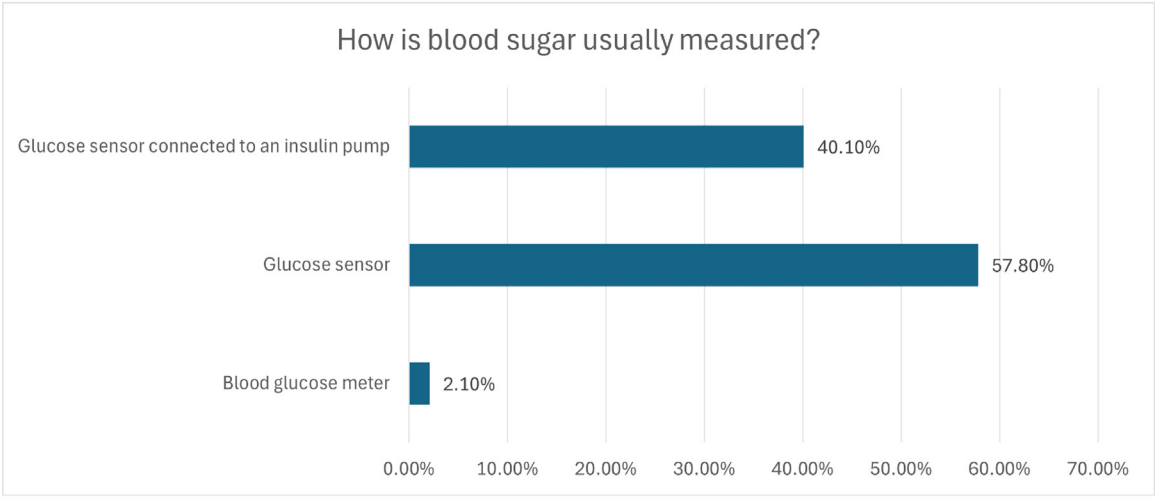
The mean year of diabetes diagnosis was 2007 ± 12.9, with a median of 2008 (IQR: 17.4), ranging from 1970 to 2025. The mean duration of diabetes was 19.2 ± 12.9 y, with a median of 18 y (IQR: 17.4), and a range from 1 to 56 y. Finally, the mean HbA1c value reported for the last 3 mo was 6.8 ± 1.2, and the mean TIR was 78.6 ± 12.3%.

Table 2
Sample and sociodemographic characteristics of patients with type 1 diabetes (N = 287)

	Mean ± SD or N (%)
Sex	
Male	67 (23.3%)
Female	220 (76.7%)
Age (y)	40.1 ± 14.0
Median (interquartile range)	37 ± 18.9
Min	18
Max	74
Young (18–30 y)	91 (31.7%)
Adults (>30 y)	196 (68.3%)
Education level	
Basic education	127 (44.3%)
Higher education	160 (55.7%)
Income level	
Low	138 (48.1%)
Medium-high	111 (38.7%)
Don't know-no answer	38 (13.2%)
Work situation	
Employed	201 (70.0%)
Unemployed	23 (8.0%)
Student	34 (11.8%)
Retired	20 (7.0%)
Do not work	9 (3.1%)
Year of diabetes diagnosis	2007 ± 12.9
Median (interquartile range)	2008 ± 17.4
Min	1970
Max	2025
Years since diabetes diagnosis	19.2 ± 12.9
Median (interquartile range)	18 ± 17.4
Min	1
Max	56
HbA1c value during the last 3 mo (%)	6.8 ± 1.2
Median (interquartile range)	6.7 ± 1.6
Min	4.2
Max	13.0
Time in range TIR (%)	78.6 ± 12.3
Median (interquartile range)	80.0 ± 16.3
Min	30
Max	100



(a)



(b)

Fig. 1. Clinical management and monitoring characteristics of the study population (N = 287). (A) Distribution of diabetes treatment modalities, highlighting the prevalence of insulin-based regimens. (B) Primary methods utilized for blood glucose monitoring indicating a high adoption rate of continuous glucose sensing technologies.

Regarding the therapeutic management of the participants, the majority relied exclusively on insulin therapy, with 54.0% using multiple daily injections and 41.8% utilizing insulin pump therapy. A small fraction of the sample reported the use of oral medications (such as metformin, GLP-1 agonists, or SGLT2 inhibitors) in combination with insulin injections (3.1%) or insulin pumps (1.0%).

In terms of glucose monitoring, the use of advanced technology was highly prevalent among the studied population. More than half of the participants (57.8%) used a standalone glucose sensor, while 40.1% utilized a sensor integrated with an insulin pump. Conversely, the use of traditional capillary blood glucose meters as the primary method of measurement was residual, reported by only 2.1% of the respondents (Fig. 1).

Cooking habits and food consumption among participants with T1DM

The analysis of cooking habits among participants with T1DM (Table 3) revealed a high frequency of home cooking (mean: 2.59,

Table 3
Cooking habits and food consumption of patients with type I diabetes (N = 287)

Variable	Mean	SD	Median	IQR
Home cooking frequency	2.59	0.76	3	1.02
Frequency of using healthy/fast appliances (e.g., air fryer, microwave)	3.26	1.27	3	1.71
Frequency of light/healthy cooking methods (e.g., grilled, steamed)	4.02	0.87	4	1.18
Frequency of heavy/unhealthy cooking methods (e.g., fried, in sauce)	2.01	0.80	2	1.08
Frequency of adding fats, sugar, or sauces to meals	1.80	0.82	2	1.11
Frequency of convenience food consumption	1.57	0.66	2	0.89

IQR, interquartile range; SD, standard deviation.

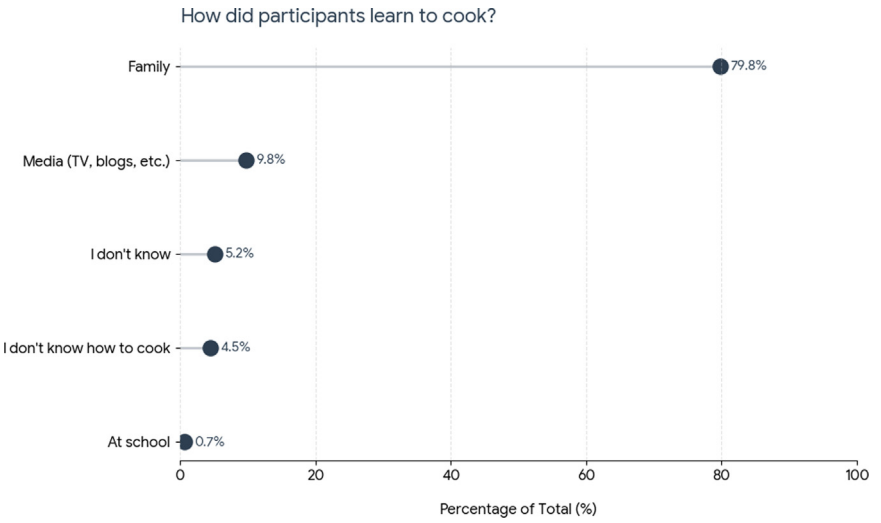


Fig. 2. Distribution of culinary learning sources among the study participants (N = 287). The data illustrates the high dependence on intergenerational family transmission compared to formal or media-based learning methods.

SD: 0.76). Regarding cooking techniques, participants reported a high adherence to light and healthy methods such as grilling or steaming (mean: 4.02, SD: 0.87), while the use of less healthy methods like frying remained low (mean: 2.01, SD: 0.80). The use of modern appliances that facilitate healthy but rapid cooking (e.g., air fryers or food processors) showed moderate frequency (mean: 3.26, SD: 1.27). Additionally, both the consumption of convenience foods and the habit of adding caloric additives (creams, butters, or sauces) to meals were reported as infrequent.

The transmission of culinary knowledge in the studied population (N = 287) is predominantly informal and rooted in the family core. As shown in Figure 2, nearly 80% (79.8%) of participants reported learning to cook through their family, highlighting the importance of domestic tradition. Media channels (including TV, books, and social media) follow as the second most relevant source (9.8%). In contrast, formal education (At school) was cited by only 0.7% of the respondents, suggesting a significant gap in institutionalized culinary training within the Spanish educational system.

Regarding the sources of culinary information and recipes among participants with T1DM (Fig. 3), digital platforms emerged as the primary tool. Almost half of the respondents (48.1%) primarily consult internet and social media channels, such as blogs, YouTube, or Instagram, to search for recipes or cooking instructions. The second most frequent source remains Family & Friends (26.8%), indicating that interpersonal transmission still plays a significant role alongside digital media. Interestingly, a notable portion of the sample (17.4%) reported that they do not follow recipes, relying instead on self-taught skills or personal invention. In contrast, traditional formats like cookbooks and television (3.8%) and professional guidance from nutritionists or specialized courses (2.4%) were cited less frequently. Notably, Artificial Intelligence tools like ChatGPT were mentioned by 1.1% of participants,

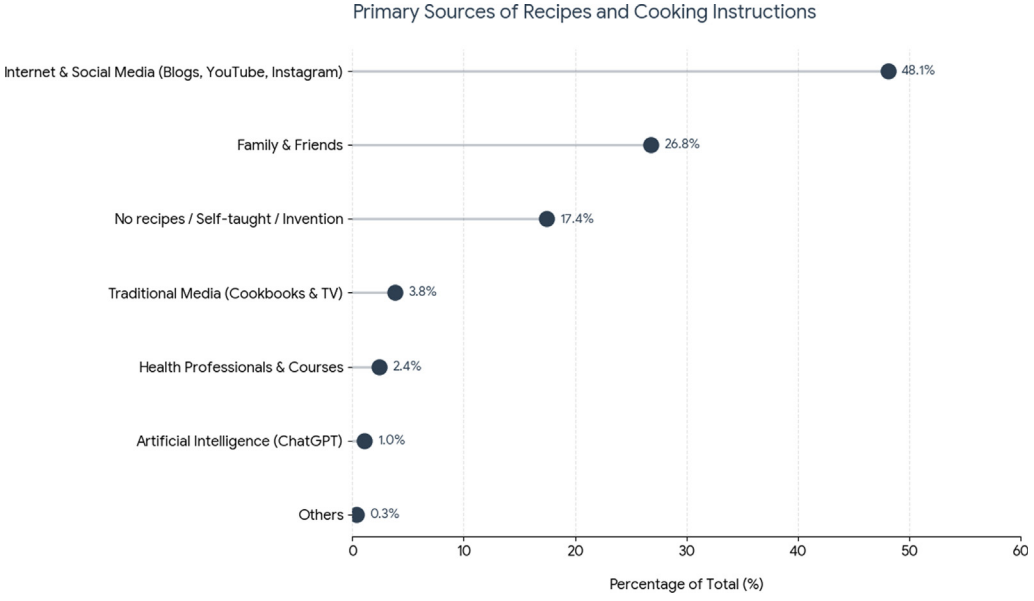


Fig. 3. Primary sources used by participants to consult recipes or obtain cooking instructions (N = 287). The chart highlights the shift toward digital platforms (48.1%) over traditional media and professional health advice.

signaling the emergence of new technologies in domestic food preparation.

The data reveals a significant generational and technological "cisma." While the fundamental basis of cooking remains deeply rooted in family tradition, specialized dietary management—such as carbohydrate counting, insulin-to-carb ratios, and healthy ingredient substitution—is no longer sought at home but in the digital cloud. This highlights a shift where the family provides the "how to cook," but the internet provides the "how to manage diabetes through cooking."

Culinary competency among participants with T1DM

Participants with T1DM demonstrated high self-perceived culinary competencies, with mean scores for most items exceeding 4.0 on a 5-point Likert scale (Table 4 and Fig. 4). The highest levels of confidence were reported in cooking vegetables (mean = 4.38, SD = 0.94) and protein foods (mean = 4.33, SD = 0.93), as well as in the use of kitchen equipment (mean = 4.25, SD = 0.99). High proficiency was also noted in reading nutritional information (mean = 4.17, SD = 1.09) and preparing balanced meals (mean = 4.29, SD = 0.91), which are critical skills for diabetes management. Conversely, the lowest confidence scores were found in weekly meal planning (mean = 3.40, SD = 1.31) and food preservation (mean = 3.68, SD = 1.21). The median score for most competencies was 5.0, indicating that more than half of the sample feels "very confident" in these tasks.

Cooking habits comparison

The examination of sociodemographic and clinical variables identified multiple statistically significant relationships with dietary patterns and cooking practices (Table 5). Concerning gender, meaningful differences were detected in both home cooking (P = 0.029) and the application of healthy techniques (P = 0.014).

Table 4
Culinary competency among participants with type 1 diabetes mellitus

Culinary competencies	Mean	SD	Median	IQR
Weekly meal planning	3.40	1.31	4.00	3.00
Food preservation	3.68	1.21	4.00	2.00
Identify the correct doneness	3.75	1.16	4.00	2.00
Read recipes	3.89	1.17	4.00	2.00
Compare food prices	3.94	1.07	4.00	2.00
Using leftovers	3.97	1.18	4.00	2.00
Modify recipe (missing ingredient)	4.04	1.05	4.00	2.00
Cooking cereals	4.05	1.11	4.00	2.00
Food safety handling	4.08	1.06	4.00	2.00
Modify recipe (healthier)	4.13	1.11	5.00	1.25
Read nutritional information	4.17	1.09	5.00	1.00
Preparatory techniques	4.20	1.17	5.00	1.00
Culinary techniques	4.22	0.99	5.00	1.00
Use of kitchen equipment	4.25	0.99	5.00	1.00
Cooking a balanced meal	4.29	0.91	5.00	1.00
Cooking of different foods	4.32	0.98	5.00	1.00
Cooking protein foods	4.33	0.93	5.00	1.00
Cooking vegetables	4.38	0.94	5.00	1.00
Total culinary education	**69.33**	**16.61**	**72.00**	**22.00**

Items were measured on a 5-point Likert scale (1 = not at all confident, 5 = very confident), except for the total score.

Female participants reported higher average scores in these domains (2.65 ± 0.71 and 4.08 ± 0.90, respectively) compared to their male counterparts, indicating a greater engagement in home-prepared meals and healthier culinary methods among women.

Age emerged as one of the most influential determinants of eating behaviors. Individuals in the older adult group (>30 y) showed significantly greater involvement in home cooking compared to younger participants ($P < 0.001$). In contrast, those aged 18 to 30 y exhibited a significantly higher propensity to employ unhealthy techniques ($P < 0.001$), consumed greater amounts of sauces/sugar (P = 0.037), and relied more frequently on Convenience Food (P = 0.008). These findings suggest a less favorable dietary profile among younger individuals relative to older adults.

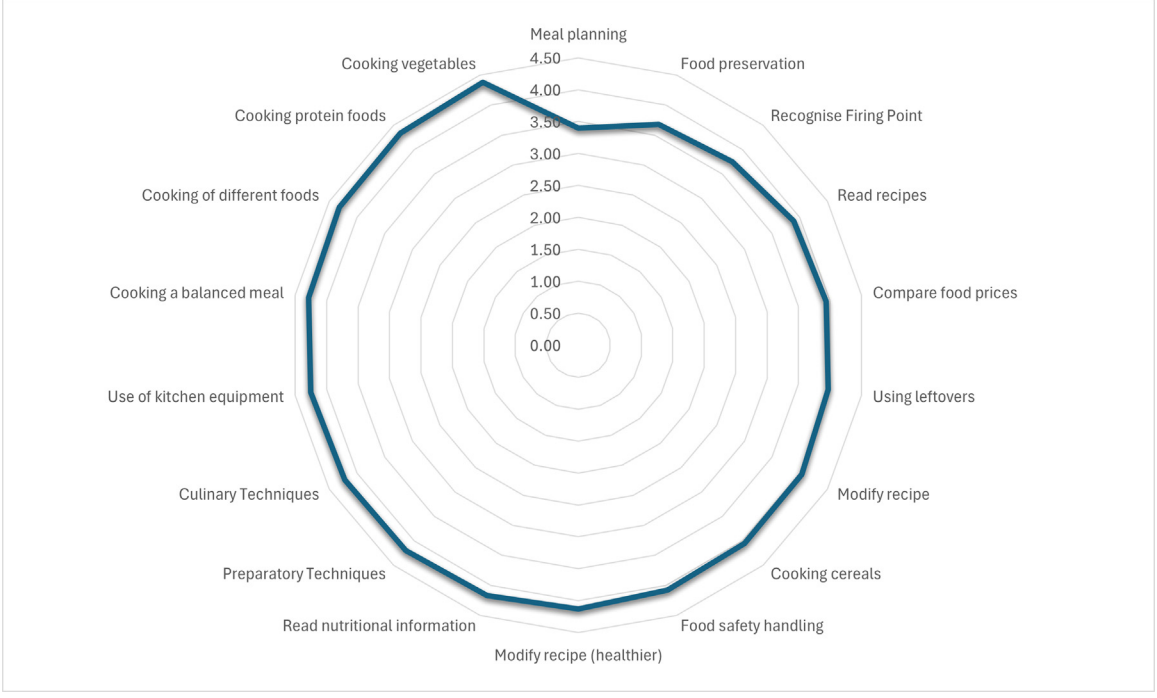


Fig. 4. Spider chart illustrates the mean scores of the 18 culinary competency items for the T1DM group.

Table 5
Culinary habits according to sociodemographic and clinical factors in patients with type I diabetes

Factor	Subgroup	Home cooking	Healthy appliances	Healthy techniques	Unhealthy techniques	Sauces/sugar	Convenience food
Sex	Male	2.40 (0.870)	3.28 (1.15)	3.85 (0.74)	2.13 (0.97)	1.84 (0.93)	1.61 (0.72)
	Female	2.65 (0.71)	3.25 (1.30)	4.08 (0.90)	1.98 (0.2)	1.79 (0.79)	1.56 (0.64)
	P value	**0.029**	0.956	**0.014**	0.394	0.955	0.806
Age	Young (18–30)	2.33 (0.93)	3.37 (1.27)	3.91 (0.94)	2.30 (0.90)	1.95 (0.86)	1.70 (0.66)
	Adult (>30)	2.71 (0.63)	3.20 (1.26)	4.08 (0.84)	1.88 (0.72)	1.73 (0.80)	1.52 (0.65)
	P value	<**0.001**	0.258	0.217	<**0.001**	**0.037**	**0.008**
Education	Basic	2.51 (0.85)	3.23 (1.21)	3.94 (0.78)	2.02 (0.81)	1.86 (0.81)	1.64 (0.70)
	Higher	2.65 (0.67)	3.28 (1.31)	4.09 (0.93)	2.01 (0.80)	1.76 (0.83)	1.52 (0.62)
	P value	0.328	0.601	**0.035**	0.898	0.202	0.221
Income	Low	2.64 (0.70)	3.12 (1.29)	4.00 (0.90)	2.01 (0.76)	1.76 (0.80)	1.59 (0.71)
	Med-high	2.56 (0.81)	3.37 (1.22)	4.04 (0.88)	1.95 (0.86)	1.76 (0.78)	1.50 (0.59)
	P value	0.518	0.125	0.767	0.397	0.998	0.486
Diabetes control	Good	2.65 (0.67)	3.31 (1.23)	4.08 (0.85)	1.95 (0.80)	1.75 (0.84)	1.52 (0.62)
	Poor	2.47 (0.89)	3.15 (1.35)	3.91 (0.90)	2.14 (0.79)	1.91 (0.78)	1.69 (0.72)
	P value	0.179	0.379	0.103	**0.037**	**0.045**	0.116
Diagnosis duration	≤10 y	2.50 (0.84)	3.23 (1.17)	4.06 (0.77)	2.11 (0.87)	1.97 (0.95)	1.58 (0.61)
	11–20 y	2.69 (0.58)	3.21 (1.36)	3.93 (0.90)	2.04 (0.81)	1.70 (0.61)	1.63 (0.63)
	>20 y	2.62 (0.76)	3.22 (1.35)	3.98 (0.93)	1.93 (0.72)	1.71 (0.80)	1.54 (0.72)
	P value	0.222	0.996	0.603	0.186	**0.021**	0.668
Treatment	Injections	2.65 (0.72)	3.15 (1.28)	4.06 (0.83)	2.06 (0.83)	1.75 (0.77)	1.55 (0.64)
	Pump	2.51 (0.81)	3.32 (1.27)	3.94 (0.93)	1.98 (0.78)	1.88 (0.89)	1.61 (0.69)
	P value	0.127	0.274	0.266	0.391	0.207	0.403
Monitoring	Sensor	2.65 (0.70)	3.16 (1.26)	4.04 (0.83)	2.06 (0.82)	1.76 (0.78)	1.55 (0.64)
	Sensor + pump	2.50 (0.82)	3.32 (1.28)	3.94 (0.95)	1.97 (0.79)	1.88 (0.90)	1.60 (0.69)
	P value	0.111	0.303	0.340	0.392	0.219	0.566

Poor diabetes control was defined as an HbA1c level ≥7% or a time in range (TIR) below 70%.
Bold values indicate statistically significant differences ($p < 0.05$).

Educational level was also significantly associated with dietary practices. Specifically, higher educational attainment was linked to a more frequent use of healthy techniques ($P = 0.035$), whereas participants with only basic education reported lower engagement in such practices. Conversely, household income did not demonstrate statistically significant differences across any of the dietary domains analyzed ($P > 0.05$), indicating that economic status alone was not a determining factor in these behaviors within the sample.

Regarding clinical characteristics, glycemic control played a significant role. Participants with suboptimal glycemic control (HbA1c ≥ 7%) presented significantly higher scores in unhealthy techniques ($P = 0.037$) and reported greater consumption of sauces/sugar ($P = 0.045$) compared to those with adequate control (<7%). Additionally, the length of time since diagnosis was significantly associated with sauces/sugar intake ($P = 0.021$), with results suggesting a gradual reduction in the consumption of these items as the duration of diagnosis increased. Importantly, no significant associations were observed between dietary factors and either the type of treatment administered (injections vs. pump) or the glucose monitoring modality used (sensor vs. sensor + pump). Finally, the use of healthy appliances remained stable across all examined subgroups, with no statistically significant differences identified for any sociodemographic or clinical variable considered.

Culinary knowledge comparison

Table 6 presents the mean total culinary knowledge (TCK) scores across different demographic and clinical subgroups. The statistical analysis identified significant differences in TCK scores according to sex and educational attainment. Female participants obtained significantly higher culinary education scores than males (71.1 ± 15.2 vs. 63.7 ± 19.7; $P = 0.006$). Likewise, individuals with higher levels of education achieved significantly greater scores compared to those with basic education (71.2 ± 14.5 vs. 66.9 ± 18.7; $P = 0.034$). No statistically significant differences were found with respect to age ($P = 0.954$) or household income ($P = 0.112$), although a tendency toward higher scores was observed among participants in the medium-high income category.

In relation to glycemic management, Diabetes control emerged as a highly significant variable ($P < 0.001$). Participants classified as having good glycemic control (HbA1c < 7%) reported notably higher TCK scores (71.8 ± 15.3) than those with poor control (64.4 ± 18.0).

Conversely, no statistically significant differences in culinary education were detected based on duration of diagnosis ($P = 0.825$), treatment modality (injections vs. pump; $P = 0.087$), or glucose monitoring approach (sensor vs. sensor + pump; $P = 0.116$). Although these associations did not reach statistical significance, slightly higher mean TCK scores were observed among participants using insulin pumps and integrated sensor–pump systems compared to those relying on injections or sensor-only monitoring.

Correlation between culinary knowledge and cooking habits

The Spearman correlation analysis (Fig. 5) revealed significant and multidimensional associations between self-perceived culinary competencies and actual domestic practices among the T1DM

Table 6
Total score of culinary knowledge by factors in patients with type I diabetes

Factor	Subgroup	Mean (SD)	*P* Value
Sex	Male/female	63.7 (19.7)/71.1 (15.2)	**0.006**
Age	Young/adult	69.3 (14.9)/69.4 (17.4)	0.954
Education	Basic/higher	66.9 (18.7)/71.2 (14.5)	**0.034**
Income	Low/med-high	68.4 (16.9)/71.7 (13.9)	0.112
Diabetes control	Good/poor	71.8 (15.3)/64.4 (18.0)	<**0.001**
Diagnosis duration	≤10 y/11–20 y/ >20 y	70.5 (15.6)/68.8 (17.7)/ 68.8 (16.8)	0.717
Treatment	Injections/pump	68.3 (17.4)/71.2 (15.8)	0.156
Monitoring	Sensor/sensor + pump	68.0 (16.9)/71.6 (15.8)	0.070

Bold values indicate statistically significant differences ($p < 0.05$).

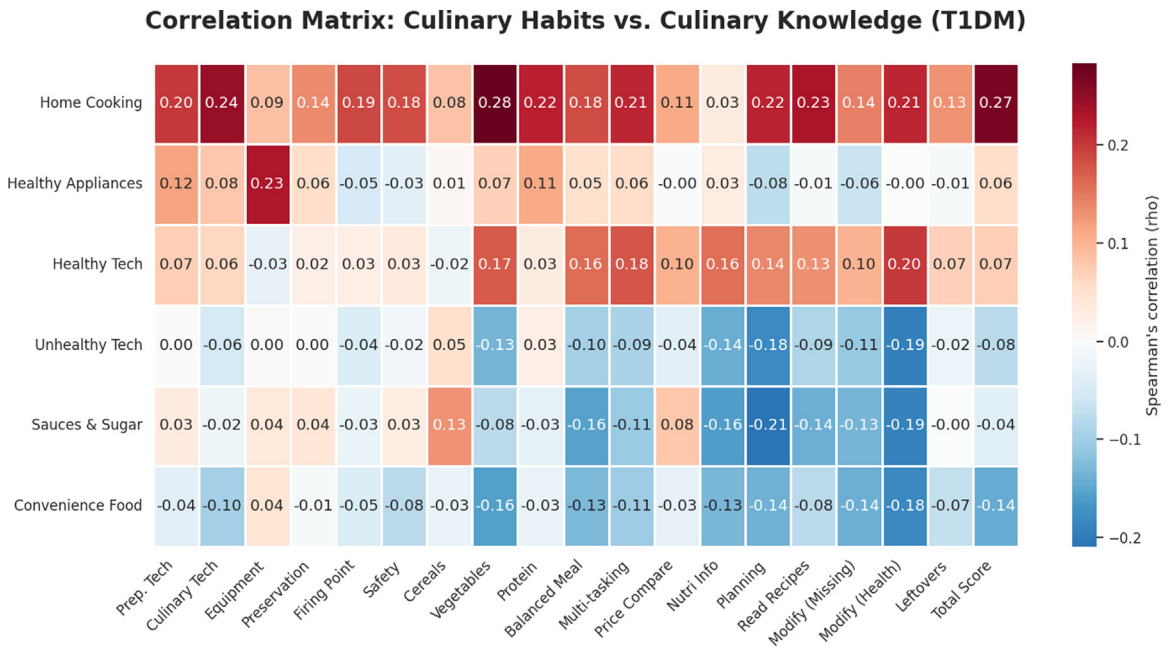


Fig. 5. Spearman's correlation matrix between culinary habits and knowledge domains in T1DM participants. Legend: The heatmap displays Spearman's rho (ρ) coefficients. Blue cells represent positive correlations, while red cells indicate inverse (negative) correlations. Home cooking frequency shows the strongest association with overall culinary self-efficacy. Notably, weekly planning skills are negatively correlated with the use of unhealthy additives, suggesting a protective role of meal organization.

population. These findings suggest that higher culinary self-efficacy is a key driver for healthier lifestyle choices in diabetes management.

The frequency of home cooking emerged as the most consistent behavioral marker, showing a robust positive correlation with the total culinary knowledge score (ρ = 0.27, $P < 0.01$). Specifically, participants who cooked more frequently at home exhibited greater confidence in fundamental skills such as vegetable preparation (ρ = 0.28), culinary techniques (ρ = 0.24), and the ability to read and interpret recipes (ρ = 0.23). This suggests a "virtuous cycle" where practical experience reinforces perceived skill, which in turn may encourage more frequent food preparation from scratch.

A direct link was observed between technological confidence and healthy habits. Confidence in the use of kitchen equipment was positively associated with the frequent use of healthy appliances—such as air fryers, steam cookers, or food processors—(ρ = 0.23, $P < 0.01$). This indicates that mastering modern culinary tools can facilitate a transition toward faster yet healthier cooking methods, which is particularly beneficial for individuals with T1DM who face time constraints in managing their diet.

One of the most clinically relevant findings was the relationship between planning and seasoning. Weekly meal planning proficiency was inversely correlated with the addition of unhealthy fats, sugars, and sauces (e.g., mayonnaise, ketchup, cream) to meals ($\rho = -0.21$, $P < 0.01$). This implies that the ability to structure a menu in advance acts as a protective cognitive factor, reducing the reliance on high-calorie, low-nutrient flavor enhancers often used in impulsive or unplanned cooking.

Furthermore, confidence in modifying recipes to make them healthier was significantly correlated with the actual use of light cooking techniques (grilling, steaming, baking). However, the moderate strength of these correlations (ρ between 0.20 and 0.30) suggests that while knowledge is a necessary foundation, the transition from "knowing how to cook" to "cooking healthy daily" is likely moderated by other factors not captured solely by knowledge, such as time availability, economic resources, or psychological burden (diabetes distress).

Discussion

This study analyzed the culinary knowledge, skills, and habits of adults with T1DM in Spain, exploring their relationship with sociodemographic characteristics, the use of technologies for disease management, and various behavioral indicators linked to glycemic control. The sample was characterized by a high level of education, extensive experience in diabetes treatment, and widespread use of advanced devices for glycemic control. It was also observed that the transmission of culinary knowledge continues to be mostly informal, while digital platforms are emerging as the main source of information. In general, participants showed a high level of self-perceived culinary competence, with variations associated with gender, age, frequency of cooking at home, and the adoption of healthier cooking techniques. Finally, the results revealed relevant links between cooking patterns and metabolic control, reinforcing the importance of cooking practices in the daily management of T1DM.

The sample analyzed in this study was predominantly female, which is consistent with recent studies conducted in Spain and Europe, where there is a slight overrepresentation of women in cohorts of adults with T1DM [39]. This is consistent with international studies that highlight that women tend to show greater interest and commitment to health education and self-care programs, which translates into greater participation in this type of studies [40].

In terms of educational level, more than half of the participants reported having a higher education. This data is relevant and consistent with the recent study by Sandri et al. [41], which states that participants with higher education have higher average scores in culinary knowledge and use healthy techniques more frequently than those with lower educational levels. Similarly, the study by Lamb et al. [42] points out that a higher level of education is

associated with better diabetes self-management and greater access to technological and educational resources.

In terms of employment status, most participants were employed. Previous research indicates that, although a significant proportion of people with type 1 diabetes are of working age, the disease can pose an additional challenge in accessing and maintaining employment [39]. This translates into insufficient adaptation of workplaces, as well as gaps in information and training within organizations. Such limitations can have a negative impact on both the employability and job stability of patients, highlighting the need to promote inclusive policies and awareness-raising actions in business and social settings [43].

In the sample analyzed, a population with extensive experience in managing T1DM was observed, which may positively influence the acquisition of self-care skills and adaptation to the therapeutic demands of the disease. Overall glycemic control was around the values recommended by international guidelines [44], although there was still considerable interindividual variability, reflecting the inherent complexity of managing T1DM.

In terms of therapeutic management, most patients depended exclusively on insulin therapy, in line with current recommendations for the treatment of T1DM [12].

Additionally, the document published by the Working Group on Technologies Applied to Diabetes of the Spanish Diabetes Society [45], highlighted the high use of advanced technology for glycemic control, suggesting rapid integration of these devices into routine clinical practice in Spain. According to the literature, this trend is associated with improvements in both metabolic control and quality of life for people with T1DM [10].

In this study, the transmission of culinary knowledge continues to be mostly informal and family-based, with formal education in this area playing a minor role. This coincides with what has been described in international literature and suggests the need to reinforce formal culinary education from an early age [41].

This gap in institutionalized culinary training within the education system has been highlighted by national and international organizations as a challenge for public health, since formal culinary education is key to developing food skills and promoting healthy habits early in life [46].

Despite advances in curriculum modernization and the inclusion of cross-curricular skills in the Spanish education system, culinary training continues to be underrepresented in official primary and secondary education programs [47]. This situation contrasts with the trend observed in other European countries, where food and culinary education has been incorporated in a structured manner into school curricula, with positive results in terms of adherence to public health recommendations [33]. Furthermore, a recent systematic review and meta-analysis confirms that healthy dietary patterns, promoted through culinary education, can have a positive impact on glycemic management in T1DM, although the magnitude of the effect varies depending on the intervention and context [48]. On the other hand, Anglo-Saxon literature highlights the usefulness of practical interventions, such as “Teaching Kitchens” programs, to improve food literacy and self-efficacy in preparing healthy meals among adolescents and adults with diabetes [49].

In terms of culinary information sources, digital platforms emerged as the primary tool, which coincides with several recent studies that indicate that the accessibility, immediacy, and diversity of content available on blogs, YouTube channels, and Instagram facilitate the search for recipes adapted to specific needs, such as carbohydrate counting or ingredient substitution, which are fundamental aspects in the dietary management of T1DM [50,51].

However, the persistence of interpersonal transmission—family and friends—as the second most frequent source underscored the importance of tradition and social learning in the formation of culinary skills. This phenomenon has been described in other European and North American contexts, where home cooking continues to be a space for socialization and intergenerational transfer of knowledge, although increasingly complemented by digital resources [52]. The fact that a significant percentage of participants do not follow recipes and rely on self-taught skills or personal invention suggests the existence of developed culinary self-efficacy, possibly linked to accumulated experience in the daily management of diabetes, where constant adaptation and individualized decision-making are essential for glycemic control. Furthermore, the lack of personalization in both conventional recipes and digital cooking apps can limit their usefulness, since each person with type 1 diabetes has specific needs related to different insulin-to-carbohydrate ratios, correction factors, or insulin sensitivity, requiring individualized adjustments in meal preparation and calculation. Previous research indicates that self-efficacy in the kitchen is associated with greater adherence to healthy eating patterns and better glycemic control in people with T1DM [53].

On the other hand, the limited use of traditional media (cookbooks, television) raises questions about the accessibility, updating, and perceived usefulness of these resources. Several studies have pointed out that, although professional nutrition education is essential for optimal diabetes management, its reach may be limited by barriers such as time, cost, or lack of adaptation to users’ technological preferences [50].

Finally, the emerging mention of artificial intelligence tools such as ChatGPT, although still in the minority, anticipates an emerging trend in the personalization and automation of culinary and educational support. International literature recognizes the potential of artificial intelligence and mobile applications to improve diabetes self-management, although it warns of the need to validate their efficacy and safety before their systematic integration into clinical practice [54].

The results obtained show a high level of self-perceived culinary competence. These findings are relevant, as these skills are fundamental pillars for dietary management and glycemic control in T1DM, as stated in the international consensus of the American Diabetes Association and the European Association for the Study of Diabetes [12]. Research in Europe and North America has shown that confidence in preparing fresh foods and handling nutritional information is associated with better adherence to dietary recommendations and greater metabolic control. Hofer et al. [15] demonstrated that individuals with greater culinary and nutritional knowledge have better results in glycated hemoglobin (HbA1c) control and time in glycemic range, underscoring the clinical relevance of these skills.

In the case of people with T1DM, the need to manage their diet more strictly could explain the greater development of specific skills, such as reading labels and preparing balanced meals.

The results obtained in this study confirm that cooking habits among the adult population with type 1 diabetes in Spain are determined primarily by sociodemographic factors, especially gender and age, rather than by clinical variables related to diabetes. This finding is consistent with previous results indicating that women tend to cook at home more often and use healthier cooking techniques, which may be influenced by cultural and historical factors that associate home cooking with the female role [35]. Furthermore, the higher frequency of home cooking and lower use of unhealthy techniques observed in adults over 30 y of age coincide with studies describing greater adherence to healthy dietary patterns, such as the Mediterranean diet, in older age groups [55].

In terms of clinical characteristics, suboptimal glycemic control in people with type 1 diabetes is associated with the adoption of

less healthy cooking techniques and higher consumption of sauces and sugars, which translates into poorer clinical outcomes and inadequate HbA1c control, consequently increasing the risk of developing metabolic complications [48]. In addition, the progressive reduction in the consumption of these products as the duration of the diagnosis increases could be interpreted as a positive adaptation and learning in dietary management over time, in line with what is described by Gómez-Peralta et al. [30], who point out the importance of experience and nutritional education in improving self-care.

Women with type 1 diabetes scored significantly higher on culinary knowledge compared to men. This finding is consistent with the international literature, which has reported that women tend to show greater involvement and self-efficacy in tasks related to food and cooking, both in the general population and in people with chronic diseases [56].

In fact, several studies indicate that women tend to take on a more active role in planning, preparing, and selecting food, which could explain their greater level of culinary knowledge [57].

In addition, sociocultural and gender socialization factors influence the acquisition and development of culinary skills, reinforcing the observed gender gap [58].

In terms of clinical factors, participants who used insulin pumps and integrated continuous glucose monitoring systems had slightly higher median scores in culinary knowledge; however, these differences were not statistically significant. Recent evidence indicates that the use of advanced technologies for diabetes management is often associated with a higher level of diabetes education, which could promote a better understanding of the nutritional and culinary aspects necessary to optimize glycemic control [12,13].

The results of this study confirmed that the frequency of cooking at home is a robust behavioral indicator, showing a significant positive correlation with the level of culinary knowledge in people with T1DM.

The use of appliances such as air fryers, steamers, or food processors is associated with the adoption of lighter cooking methods. From a food science perspective, air-frying significantly reduces oil uptake and the formation of harmful compounds, such as acrylamides, compared to traditional deep-frying [56]. However, regarding glycemic management, the clinical rationale for discouraging fried foods must be clearly distinguished between type 1 and type 2 diabetes. As noted in the literature, the adverse metabolic outcomes and long-term insulin resistance mechanisms associated with frequent fried food consumption are predominantly documented in populations with type 2 diabetes or at risk of developing it [59–61]. In contrast, individuals with T1DM can often tolerate fried foods adequately if the carbohydrate load and breading are accurately quantified. The primary challenge in T1DM arises from the acute postprandial dynamics: the high fat content inherent to deep-fried meals induces delayed gastric emptying and transient insulin resistance. This physiological response typically leads to early postprandial hypoglycemia followed by late hyperglycemic excursions (often 3–6 h after eating), which severely complicates the calculation and timing of prandial insulin boluses [62–64]. Therefore, the use of alternative cooking methods like air-frying in T1DM is advantageous not because it reverses underlying insulin resistance, but because it significantly reduces the dietary fat load of the meal, thereby facilitating more predictable acute postprandial glucose excursions and improving daily glycemic management.

In terms of meal planning, an inverse correlation was observed between the ability to plan weekly and the addition of unhealthy fats, sugars, and sauces. As this is a cross-sectional study, it allows us to identify patterns and associations, but not the direction or causal nature of the relationships observed. Therefore, although meal planning is associated with healthier cooking habits, it cannot be said that one behavior is a consequence of the other. However, several international studies support the idea that meal planning acts as a protective factor, reducing the likelihood of resorting to calorie-rich flavor enhancers and promoting the structuring of balanced menus [65].

Additionally, planning is associated with greater adherence to healthy dietary patterns and better glycemic control in people with T1DM.

Taken together, these findings suggest that educational interventions targeting people with type 1 diabetes should encourage both the development of cooking skills and the integration of healthy household technologies and meal planning to promote a healthier and more sustainable diet over time.

Strengths and limitations

A primary strength is the robust sample size (N = 287), which substantially exceeded the minimum requirement of 196 participants calculated for a 95% confidence level. The dissemination of the questionnaire through social networks and patient associations allowed reaching people with type 1 diabetes quickly and efficiently across the Spanish territory, facilitating the obtaining of a large and heterogeneous sample that would be difficult to capture through traditional methods. Moreover, the research addresses a critical gap in the literature by shifting the focus from theoretical nutritional knowledge to practical culinary self-efficacy, a key but often overlooked component of diabetes self-management. The methodology is further strengthened by the use of a culturally adapted and previously validated instrument, supplemented by expert-designed items that capture modern culinary trends, such as the use of air fryers or digital recipe sources. The comprehensive nature of the data—integrating sociodemographic, clinical, and behavioral variables—allows for a multidimensional understanding of how culinary habits are formed in this population. Lastly, the identification of the “technological shift” in culinary learning provides actionable insights for healthcare providers, highlighting the need to integrate digital tools and culinary training into modern diabetes education programs.

However, some limitations should be noted. First, the study population exhibits a notable gender imbalance, with women representing 76.7% of the participants. This overrepresentation may reflect traditional sociocultural patterns in Spain, where women have historically assumed a more prominent role in household food management [66]. Furthermore, more than half of the sample (55.7%) reported having attained higher education, suggesting a potential selection bias toward individuals with greater health literacy.

The recruitment method also presents specific challenges to the generalizability of the results. The use of non-probabilistic snowball sampling via social media and diabetes associations creates a “digital divide” barrier. This approach likely excluded individuals with limited technological proficiency or those not active in digital patient communities, which is particularly relevant given that nearly half of the respondents (48.1%) now rely on digital platforms for culinary guidance. Additionally, the reliance on self-reported data for clinical variables, such as HbA1c levels or TIR, introduces the possibility of recall bias or social desirability [67]. However, recently published studies indicate that self-reported HbA1c largely agrees with laboratory-measured HbA1c in people with type 1 diabetes [68]. Finally, the study did not evaluate actual food intake, but only culinary habits and perceptions, which limits the possibility of relating these practices to the participants’ actual eating.

Recommendations

Future research could include longitudinal studies or interventions are required to determine whether improving cooking skills, menu planning, and the use of healthy techniques translates into better metabolic outcomes. It is necessary to complement the self-report with more robust indicators, such as dietary records, diet quality metrics, or practical tests of culinary skills, to verify the agreement between what people report and what they actually do. The results point to the importance of studying specific profiles: young people who are starting independent living, people with lower educational levels, or patients with suboptimal glycemic control. This would allow for the design of more tailored and effective interventions.

Conclusion

The findings of this study lead to the conclusion that culinary self-efficacy is a fundamental pillar for the effective management of T1DM within the Spanish population. It was observed that individuals with higher culinary knowledge and better preparation skills achieved significantly better metabolic outcomes, evidenced by lower HbA1c levels and higher TIR. This relationship suggests that practical cooking skills are not merely a domestic convenience but a clinical asset that facilitates adherence to complex dietary requirements.

The research also identifies a significant "technological shift" in how culinary knowledge is acquired and utilized. Although basic cooking techniques remain deeply rooted in intergenerational family transmission, specialized management—such as carbohydrate counting and healthy ingredient substitution—has migrated to digital platforms and social media. This highlights a growing gap between traditional domestic training and the modern needs of diabetes self-care, which is currently being filled by the "digital cloud" rather than formal health or educational institutions.

Furthermore, the study confirms that sociodemographic factors, particularly gender and age, continue to exert a strong influence on dietary behaviors. Women and older adults demonstrate a greater commitment to home cooking and the use of healthy techniques, whereas younger populations exhibit a less favorable profile characterized by higher consumption of convenience foods and unhealthy additives. This underscores the necessity for targeted educational interventions that go beyond theoretical nutrition. To promote sustainable health outcomes, healthcare providers must integrate practical culinary training, digital literacy, and meal-planning strategies into official diabetes education programs.

Ethical approval and informed consent

The research strictly followed ethical principles outlined in the Declaration of Helsinki and received approval from the Ethics Research Committee of the Catholic University of Valencia (approval number UCV/2024-2025/144, June 4, 2025). Prior to participating, explicit informed consent was obtained from all individuals, ensuring they were fully informed about the study's objectives, procedures, and potential risks, and emphasizing the voluntary nature of their participation.

Data availability

The data presented in this study are available upon reasonable request to the corresponding author.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article. All authors have read and agreed to the published version of the manuscript.

CRediT authorship contribution statement

Adrián Idoate-Bayón: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Barbara Gómez-Taylor:** Writing – review & editing, Resources, Project administration. **Jorge Casaña Mohedo:** Writing – review & editing, Visualization, Resources. **Francisca Esteve-Claramunt:** Writing – review & editing, Writing – original draft, Validation, Resources. **Miryam Vacas-Cortés:** Writing – review & editing, Resources, Data curation. **Marina Gómez Pérez:** Writing – review & editing, Resources, Data curation. **Rocío Práxedes Gómez:** Writing – review & editing, Resources. **Elena Sandri:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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