



## Trabajo Original

Obesidad y síndrome metabólico

### Type 2 diabetes *mellitus*, obesity, cesarean section delivery, and lack of exclusive breastfeeding exposure in patients from the Guadalajara Metropolitan Area, Mexico *Diabetes mellitus de tipo 2, obesidad, parto por cesárea y falta de exposición a la lactancia materna exclusiva en pacientes de la Zona Metropolitana de Guadalajara, México*

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#### Abstract

**Introduction:** the combination of cesarean section delivery and limited exposure to full breastfeeding (FBF) in the first six months of life may increase the risk of obesity and diabetes *mellitus*. This study aimed to establish an association between type 2 diabetes *mellitus* (T2DM) in adulthood, cesarean section delivery and incomplete full breastfeeding (FBF) in individuals from the metropolitan area of Guadalajara, Mexico.

**Methodology:** this analytical cross-sectional study included patients over 18 years of age with T2DM and normal weight, overweight or obesity, regardless of sex. Informed consent was obtained. Variables encompassed T2DM, type of delivery method, first-year diet, family history, demographic, socioeconomic, and educational characteristics, and anthropometric measurements. For statistical analysis, Student's t test, chi-square tests and odds ratios were employed.

**Results:** the study evaluated 218 patients with an average age of 57.8 years ( $\pm 12.7$ ) and an average age at T2DM diagnosis of 46.2 years ( $\pm 12.5$ ). FBF (65.6 %) and partial breastfeeding (PBF) (23.8 %) prevailed in the first six months. The average age at T2DM diagnosis was 46.7 years ( $\pm 12.1$ ) for vaginally born patients and 30.7 years ( $\pm 15.5$ ) for cesarean-born patients ( $p = 0.001$ ). Cesarean delivery increased obesity risk by nine times in patients with T2DM [OR = 8.9 (CI, 1.05, 75.2),  $p = 0.02$ ].

**Conclusion:** prioritizing the limitation of nonmedically justified cesarean section deliveries is crucial to mitigate the risk of obesity and T2DM in adulthood.

#### Keywords:

Diabetes *mellitus* type  
2. Obesity. Birth method.  
Diet type.

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## Resumen

**Introducción:** la combinación de parto por cesárea y exposición limitada a la lactancia materna completa (LMC) en los primeros seis meses de vida puede aumentar el riesgo de obesidad y diabetes *mellitus*. Este estudio tuvo como objetivo establecer una asociación entre la diabetes *mellitus* de tipo 2 (DM2) en la edad adulta, el parto por cesárea y la lactancia materna incompleta (LMI) en individuos del área metropolitana de Guadalajara.

**Metodología:** este estudio transversal y analítico incluyó pacientes mayores de 18 años con DM2 y normopeso, sobrepeso u obesidad, independientemente del sexo. Las variables abarcaron la DM2, el tipo de método de parto, la dieta del primer año, los antecedentes familiares, las características demográficas, socioeconómicas y educativas, y las medidas antropométricas. Se utilizaron las pruebas t de Student, chi-cuadrada y odds ratio.

**Resultados:** el estudio evaluó a 218 pacientes con una edad promedio de 57,8 años ( $\pm 12,7$ ) y una edad promedio al diagnóstico de DM2 de 46,2 años ( $\pm 12,5$ ). En los primeros seis meses prevalecieron la lactancia materna (65,6 %) y la lactancia materna parcial (23,8 %). La edad promedio al diagnóstico de DM2 fue de 46,7 años ( $\pm 12,1$ ) para los pacientes nacidos por vía vaginal y de 30,7 años ( $\pm 15,5$ ) para los pacientes nacidos por cesárea ( $p = 0,001$ ). El parto por cesárea aumentó nueve veces el riesgo de obesidad en pacientes con DM2 [OR = 8,9 (IC: 1,05, 75,2),  $p = 0,02$ ].

**Conclusión:** es crucial priorizar la limitación de los partos por cesárea no justificados por razones médicas para mitigar el riesgo de obesidad y DM2 en la edad adulta.

### Palabras clave:

Diabetes *mellitus* de tipo 2. Obesidad. Método de nacimiento. Tipo de dieta.

## INTRODUCTION

Approximately 80 % of the population living with type 2 diabetes *mellitus* (T2DM) resides in low- or middle-income countries, and Mexico ranks among the top 10 countries with the highest prevalence of this pathology (1). In 2022, the National Health and Nutrition Survey reported an increase in the frequency of T2DM to 12.6 % (2). T2DM is a complex disorder involving the interaction of genetic and environmental factors (3). These factors produce heritable changes in gene function without modifying the DNA sequence. For instance, environmental factors include diet and exercise (4). Epigenetic studies on T2DM and obesity have revealed an association between DNA methylation and certain metabolic traits. In obesity, this DNA methylation can lead to increased production of fat cells, along with mutations in genes related to insulin resistance (4,5).

Likewise, a global increase in the incidence of cesarean sections has been documented, and there is speculation that the combination of a higher incidence of cesarean sections and lower exposure of infants to exclusive breastfeeding (EBF) during the first six months of life may increase the risk of obesity and T2DM (6). Currently, only a limited number of conclusive studies associate breastfeeding with a lower risk of obesity in adults (7) or the potential risk of overweight and obesity in adulthood for newborns who are born via cesarean section (8). Few publications have explored the association among cesarean section delivery, obesity, and T2DM. Alternatively, studies have analyzed the risk of T2DM in patients born by cesarean section with or without exposure to breastfeeding (9). In Mexico, we have found no evidence of research analyzing these factors simultaneously. Therefore, this study aimed to demonstrate that cesarean section delivery and nonexposure to breastfeeding favor the development of obesity and T2DM.

## MATERIAL AND METHODS

In this analytical cross-sectional study, patients with T2DM who visited the Mexican Diabetes Association in Jalisco and

Hospital Civil de Guadalajara Dr. Juan I. Menchaca were included from January 1, 2022, to October 31, 2022. Patients from both locations participated. Patients aged over 18 years with normal weight, overweight or obesity were included, regardless of sex. Informed consent was obtained from all participants. The exclusion criteria encompassed individuals with a history of congenital or genetic diseases, pregnant and/or lactating women with T2DM, individuals born via cesarean section due to aggravated maternal or fetal clinical conditions, mothers with drug addiction, and individuals who received medications for medical reasons. Patients with incomplete records and individuals who were unable to undergo anthropometric measurements were also excluded.

The following equation was utilized for sample size calculation:  $n = (Z - \alpha/2 + Z - \beta)^2 * p(1 - p) / e^2$ , where  $\alpha/2$  is the level of significance or probability of type 1 error ( $0.05 / 2 = 1.96$ ),  $\beta$  is 80 % power (0.84), and  $p$  is a probability of 50 % due to a lack of knowledge of the true prevalence of cesarean section delivery. In addition,  $e^2$  is the accepted error of the true frequency of cesarean section delivery ( $0.1$ )<sup>2</sup>. The probability of exclusions was 30 % = 46 with an  $n = 200$ . Nonprobabilistic sampling was carried out at the included sites. The general characteristics of the patients were considered, including the socioeconomic level, evaluated by the index of the Mexican Association of Market and Opinion Intelligence Agencies (AMAI), which considers seven index levels (10), a history of direct family members with T2DM and anthropometric measurements. In addition, the diet type in the first semester of life and the delivery method were determined.

## MEASURING INSTRUMENTS AND TECHNIQUES

Data on the direct anthropometric indicators, weight, and height were obtained, and the body mass index (BMI) was estimated. Weight and body composition were measured using the Tanita Body Composition Analyzer instrument, model TBF-410GS (Tokyo, Japan). Height measurement was performed with a Seca wall stadiometer, model 213 (Seca, Hamburg, Germany). Mea-

surements were taken with the subject standing, without shoes or anything on the head. The subject stood with their back upright and their head, shoulders, buttocks, and heels together while touching the vertical surface of the instrument. Care was taken to ensure weight distribution on both feet; both arms were kept at the sides in a relaxed manner, and the axis of the eye and the external auditory canal were aligned horizontally. The patient was asked to inhale deeply and then lower the moving part of the stadiometer, and the measurement closest to 0.1 cm was recorded. Once the patient's weight and height were obtained, the BMI was estimated in points.

### STATISTICAL ANALYSIS

The Kolmogorov-Smirnov test was utilized to verify the normal distribution of the variables. Descriptive statistics for quantitative variables (average and standard deviation) and for qualitative variables (percentages and frequencies) were obtained. Subsequently, the unpaired Student's t test was employed to illustrate the contrast between two independent samples in quantitative variables with a normal distribution, while nonparametric association tests such as the chi-square test were used for the analysis of qualitative variables. The results indicating a significant association are expressed as odds ratios to estimate their epidemiological significance.

### ETHICAL CONSIDERATIONS

The research did not pose any risk to the study subjects, and the protocol adhered to the guidelines of the Declaration of Helsinki, as per its latest revision during the 64th Annual Assembly organized by the World Medical Association (2013). Informed

consent was obtained from the selected patients, and the protocol was submitted to the Bioethics and Research Committee of the Nuevo Hospital Civil de Guadalajara Dr. Juan I. Menchaca (Opinion no. 17CI14 039 116).

### RESULTS

The majority of participants were women (63.8 %). Average age was  $57.8 \pm 12.7$  years. The average age at the diagnosis of T2DM was  $46.2 \pm 12.5$  years. When dividing the sample into women and men, there was no significant difference (46.7 and 45.3 years, respectively). The time elapsed since the diagnosis of T2DM showed a median of 10 years (range: 1-44 years). The majority of patients were in the sixth stage of life. The age difference according to sex and diagnosis of T2DM was not significant (women,  $58.0 \pm 12.9$  years; men,  $59.4 \pm 12.6$  years).

Most of the patients (43.6 %) included in the study were married by civil law and some were married by religion. The number of patients distributed by sex and marital status appears in table I. A significant association was observed with a greater number of civil and religious marriages and common-law marriages in men and a higher percentage of widows ( $p = 0.01$ ). In particular, it was observed that widowhood was five times more frequent in women than in men [OR = 5.2 (CI, 1.53, 18.1),  $p = 0.004$ ], while civil and/or religious marriage and common-law union vs. other marriage types showed a frequency almost three times higher in men than women [OR = 2.77 (1.5, 5.12),  $p < 0.001$ ].

The majority of patients (28 %) were at socioeconomic level C. The average age at the time of diagnosis of T2DM in patients who were born vaginally was  $46.7 \pm 12.1$  years, while in patients who were born by cesarean section, it was  $30.7 \pm 15.5$  years ( $p = 0.001$ ). Furthermore, when the BMI category was divided between normal weight and overweight vs. obesity.

**Table I. Number of patients described and distributed by marital status**

Civil status	Females, n (%)	Males, n (%)	p
Civil and religious marriage	54 (38.8)	41 (51.9)	0.010
Civil marriage	11 (7.9)	6 (7.6)	
Religious marriage	1 (0.7)	0 (0)	
Free union	8 (5.8)	13 (16.5)	
Separate	6 (4.3)	0 (0)	
Divorced	8 (5.8)	3 (3.8)	
Single mother or father	5 (3.6)	2 (2.5)	
Widower	24 (17.3)	3 (3.8)	
Single	22 (15.8)	11 (13.9)	
Total	139 (100)	79 (100)	

Statistical test: Chi-square. Civil and/or religious marriage and free union vs. others: men vs. women [OR = 2.77 (CI, 1.5, 5.12),  $p < 0.001$ ].

**Table II.** Number of patients distributed by type of delivery method and BMI category

Birth type	Obesity		Normal weight and overweight		p
	n	%	n	%	
Via cesarean section delivery	6	6.6	1	0.8	0.02
Via vaginal delivery	85	93.4	126	99.2	
Total	91	100	127	100	

Statistical test: Chi-square. Cesarean section delivery increased the probability of obesity by nine times [OR = 8.9 (CI, 1.05, 75.2), p = 0.02].

**Table III.** BMI score classification divided by sex. The number of female and male patients with normal weight, overweight and obesity was 218

	Females	Males	p
<i>BMI</i>			
Normal weight	20 (14.5 %)	18 (22.8 %)	0.031
Overweight	51 (37.0 %)	37 (46.8 %)	
Obesity	67 (48.2 %)	24 (30.4 %)	
Total	139 (100 %)	79 (100 %)	
<i>Normal vs. obesity</i>			
Normal weight	20 (23.0 %)	18 (42.9 %)	0.020
Obesity	67 (77.0 %)	24 (57.1 %)	
Total	87 (100 %)	42 (100 %)	
<i>Overweight vs. obesity</i>			
Overweight	51 (43.2 %)	37 (60.7 %)	0.027
Obesity	67 (56.8 %)	24 (38.3 %)	
Total	118 (100 %)	61 (100 %)	

Statistical test: Chi-square (p = 0.102). The frequency of overweight was twice as high in males than in females [OR = 2.02 (CI, 1.07, 3.8), p = 0.029]; the frequency of obesity was 2.5 times higher in females [OR = 2.5 (CI, 1.14, 5.5), p = 0.02].

The frequency of births via vaginal was 96.8 % and via cesarean section delivery 3.2 %. It was observed that cesarean section delivery increased the probability of obesity by nine times [OR = 8.9 (CI, 1.05, 75.2), p = 0.02] in patients who developed T2DM, as shown in table II. No significant association was observed between the type of delivery method and the different types of feeding during the infancy stage FBF (65.6 %), PBF (23.8 %) and human milk substitutes (HSM) (10.5 %).

A larger proportion of patients were overweight (40.8 %) or obese (41.8 %). When dividing patients by the BMI score and sex, a significant association was observed. Obesity predominated in women, and overweight was more common in men. The frequency of obesity was 2.5 times higher in females [OR = 2.5 (CI, 1.14, 5.5), p = 0.02], while overweight was twice as common in men [OR = 2.02 (CI, 1.07, 3.8), p = 0.029], as shown in table III.

## DISCUSSION

The average age at T2DM diagnosis was 46.2 years, while globally, the diagnosis typically occurs at an older age (55 to 59 years). In a study carried out by Tinajero et al. (11) (2021) worldwide, it was observed that T2DM manifests itself at an earlier age in men than in women. However, in our study, upon dividing the sample by sex, we found that the average age of diagnosis in women was 45.3 years vs. that of 46.7 years in men. The average age at T2DM diagnosis showed significant differences between patients delivered by cesarean section versus vaginally. In patients born by cesarean section, T2DM diagnosis occurred at a younger age compared to those born vaginally (30.7 vs. 46.7 years, respectively) (p = 0.001). A similar finding was previously reported (9). In our study, it was found that the probability of obesity was approximately nine

times higher in patients born via cesarean section than in patients born vaginally. Although higher, this result aligns with an international study (12), where patients born via cesarean section showed a twofold risk of being overweight or obese at the age of 20 years in the Danish population.

In the group of patients studied, the delivery method (vaginal delivery vs. cesarean section) was not associated with the type of feeding in the first six months of life (FBF, PBF human milk substitutes). This result contrasts with what was reported by other authors, where higher BF rates were found after vaginal birth vs. cesarean section delivery (13,14). When analyzing the type of diet of our patients in the first six months of life, it was found that the frequency of FBF was 65.6 %, while national surveys reported a similar frequency of 68.8 % in 2018. It was observed that in the majority of the patients studied, continuous breastfeeding lasted for an average of 12 months; this finding coincides with what is described in the ENSANUT (15,16). There was no relationship between the type of feeding and BMI, suggesting that, in the studied population, the protective effect of BF against overweight and obesity was not present. Similar results were obtained in another study carried out in Mexico (17). Therefore, we consider that more information is needed to adequately interpret these results on the potential effect of the type of diet on BMI in patients with T2DM.

It was observed that a greater proportion of patients (82.6 %) were overweight (40.8 %) or obese (41.8 %). An analysis of these data, dividing the patients by sex, showed that women were almost three times more likely to be obese than men, while men showed a higher frequency of overweight (46.8 %). These data coincide with what was reported by the ENSANUT in 2022, where the majority of women were obese (41.0 %), while the majority of men were overweight (41.2 %) (18).

## STRENGTHS AND LIMITATIONS

*Strengths:* the information obtained in our study revealed that cesarean section delivery increased the probability of obesity by nine times in patients with T2DM. This information has not been previously documented in our country.

*Limitations:* the frequency of cesarean section delivery was lower than expected (3.2 %). Additionally, there could be a memory bias among the studied participants related to the frequency and duration of breastfeeding.

## CONCLUSIONS

Patients with T2DM who were born via cesarean section were nine times more likely to present with obesity in adulthood than those born vaginally. Therefore, it is necessary to carry out cohort

studies that demonstrate a causal relationship between cesarean section delivery and T2DM.

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