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Epidemiological panorama of type 2 diabetes in Mexico: differences by state and social determinants

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Abstract

Introduction: *Type 2 diabetes mellitus (T2DM) is a public health problem with an impact on individuals and society.* **Objective:** *The study aimed to describe the rates of variation and the rate of growth of the prevalence and mortality of T2DM in the states of Mexico, in relation to the figures of multidimensional poverty and indicators of social deprivation, the Human Development Index, the Gini Coefficient and GDP per capita.* **Material and methods:** *An ecological study was carried out with information from official open access sources in Mexico, the prevalence and mortality of T2DM were analyzed. The entities were grouped according to their rates of change, and their growth rates were analyzed according to the socio-economic context. A correlation analysis was performed between the rate of variation of mortality and the prevalence of T2DM with the percentage of the population living in extreme poverty.* **Results:** *Both indicators have increased in all entities at different rates. The poorest states, with the lowest Human Development Index and GDP and the highest Gini coefficient have been the most affected. The correlation showed that, the higher the level of extreme poverty, the higher the increase in mortality and the prevalence of T2DM.* **Conclusion:** *If the care strategy is not modified, this accelerated increase will mainly affect the poorest entities, which, due to their access to health services and living conditions, will have more far-reaching consequences.*

Keywords: *Type 2 diabetes. States. Social determinants of health. Mortality and prevalence.*

Introduction

In Mexico, between 2000 and 2016, mortality from Type 2 diabetes mellitus (T2DM) increased by 5%; it is estimated that, worldwide, it is the main cause of blindness, kidney failure, heart attack, cerebrovascular event, and amputation of lower limbs[1]. About 10.5% of adults between 20 and 79 years of age have this disease and by 2030 and 2045, there will be 643 and 783 million people with T2DM, respectively. In addition, 94.0% of this increase is expected to occur in low- and middle-income countries[2]. This research focuses on T2DM, which accounts for about 90% of all diabetes cases and 70% of deaths[3]. In this study, it is argued that both the increase in prevalence and mortality due to T2DM[3] are the result of a complex network of social determinants of health (SDH), which, according to the World Health Organization (WHO), are "the circumstances in which people are born, grow, work, live, and age, including the broader set of forces and systems that influence the conditions of daily life"[4]. The analysis of these

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determinants lies in identifying how inequities in the distribution of social goods are manifested by generating unfair differences in the health status of social groups[5,6].

Once the diagnosis has been made, the main objective of the health system is to ensure effective control of diabetes. In Mexico, both strategies and programs have focused on direct causes, such as risk factors (which, by definition, according to authors such as Jenicek[7], are modifiable conditions), and, on the other hand, they have not been able to have an impact on the detection and control of the disease (which depend more on prognostic factors). Some explanations for this refer to the inaccessibility of health services (geographical, economic, and/or cultural), and the poor quality of care they offer[8-10].

The percentage of the population aged 20 years and over with a previous medical diagnosis of diabetes in 2018 was 10.3%[11]. In 2016, the total prevalence of diabetes was 13.7% (9.5% diagnosed, 4.1% undiagnosed); 68.2% of the individuals diagnosed had glycemic imbalance, compared to 94.5% in 2006[12]. This reflected a decrease in the figures; however, the proportion of people with glycemic decontrol continues to be high. According to the ENSANUT 2021[13], the prevalence of people aged 20 years and over with a previous medical diagnosis of T2DM was 10.2%. However, from venous blood samples, it was found that this prevalence was 15.8%, (that is, the percentage of people who were unaware that they had the disease), thus, the overall prevalence was 26%. The objective of this study was to describe the rates of change and the growth rate of the prevalence and mortality due to T2DM in the states of Mexico, in relation to the figures of multidimensional poverty and indicators of social deprivation, the Human Development Index, the Gini Coefficient and GDP per capita.

Material and methods

An ecological study[14] was carried out to analyze the behavior of prevalence and mortality in Mexico, by state. The data were obtained from official open access sources. The prevalence by state was collected from the National Health and Nutrition Surveys (ENSANUT) 2000, 2012, 2016, 2018, 2020, and 2021 of the National Institute of Public Health[15], mortality, from the death registry of the National Institute of Statistics and Geography (INEGI)[3,16,17] and to calculate the rates, the population projections of the National Population Council (CONAPO) were used[18]. The health data were contrasted with multidimensional poverty figures and indicators of social deprivation, from the National Council for Social Development Policy (CONEVAL) 2020[19], with the Human Development Index (HDI)[20], the Gini Coefficient[21], and GDP *per capita*[22], during the period 2000-2020.

The rates of change in prevalence and mortality were calculated to analyze their growth rates in the States. That is, the positive change in the percentage of a variable between two different moments of time was analyzed**.** The entities were grouped into four groups (G) according to the position that they occupied in both years studied: G1, occupied the last positions of prevalence and mortality in both years; G2, went from low to high or medium levels; G3, high levels in the 1st year and low levels in the last year, and G4, were positioned in the first places in both years:

$$Cluster\ 1 = Entity\ (Position\ t1\ {}^{32}_{20}\ \wedge\ Position\ t2\ {}^{32}_{20})$$

$$Cluster\ 2 = Entity\ (Position\ t1\ {}^{20}_{32}\ \wedge\ Position\ t2\ {}^{1}_{19})$$

$$Cluster\ 3 = Entity\ (Position\ t1\ {}^{1}_{19}\ \wedge\ Position\ t2\ {}^{20}_{32})$$

$$Cluster\ 4 = Entity\ (Position\ t1\ {}^{1}_{19}\ \wedge\ Position\ t2\ {}^{1}_{19})$$

Where:

t1= 2000

t2 = 2018 in the case of prevalence and 2019 in the case of mortality, and the superindex and subindex numbers refer to the position they occupied in both years. Finally, a correlation analysis was made between the rate of change in mortality (2000-2019) and the rate of change in the prevalence of diabetes (2000-2018) with the percentage of the population in a situation of extreme poverty in 2020.

Results

Pattern and rate of growth of T2DM prevalence by state in Mexico from 2000 to 2018 and socioeconomic indicators

The lowest prevalence of T2DM in Mexico went from 3.2% in 2000 to 7.4% in 2018 and the highest prevalence, from 7.9% in 2000 to 14.0% in 2018. The highest prevalences in 2000 were observed in the north-east of the country, which continued in 2018 and were also added to southeastern entities such as Veracruz, Tabasco, and Campeche, and those of Hidalgo, Morelos, and Mexico City (Fig. 1).

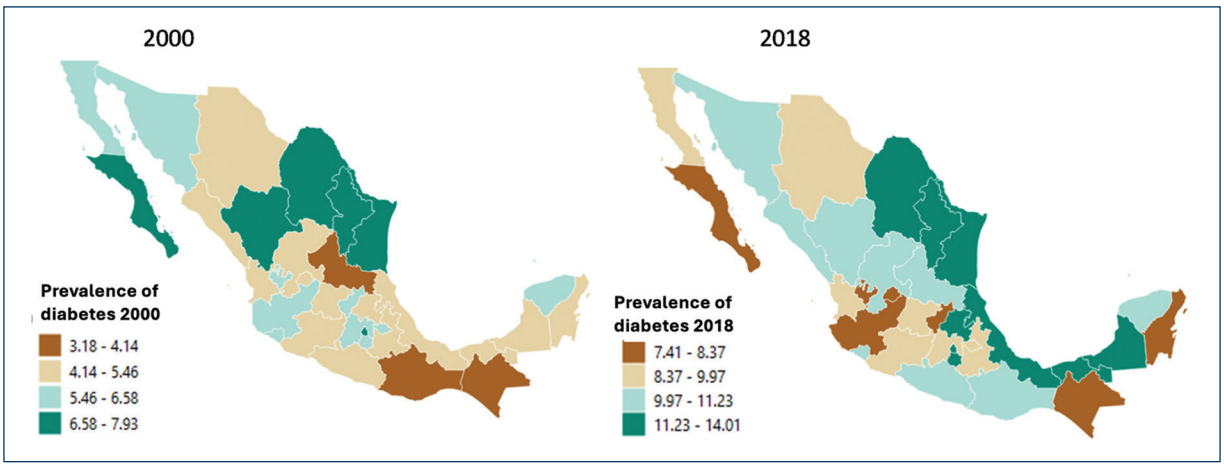

Figure 1. Mexico: prevalence of diagnosed diabetes, 2000-2018
(authors' elaboration based on data from the National Institute of Public Health's ENSANUT 2000 and 2018).

Between the 2 years, the growth rate of T2DM prevalence ranged from 219.5% in Oaxaca to 15.0% in Baja California Sur (BCS) and Jalisco (JAL). Within the G1, Chiapas and Quintana Roo stood out for presenting the lowest levels of prevalence in both years. In the G2, Campeche, Guerrero, Oaxaca, and Tabasco stood out, states that during the year 2000 showed the lowest prevalences and in 2018 occupied the first places. In the G3, entities such as Jalisco and BCS went from high to low prevalence between 2000 and 2018.

Finally, in the G4, entities such as Tamaulipas, Nuevo León, Coahuila, Mexico City and Sonora, were located within the 10 with the highest levels of diabetes in both years. Some of the G2 states, such as Chiapas, Guerrero and Oaxaca, whose growth was greater than 110.0%, had an HDI below the national average, the Gini above the average, which reflects greater inequality and the GDP per capita below the national average, with the exception of Campeche and Tabasco (Table 1).

Mortality due to T2DM in Mexico

From 2000 to 2019, it went from 47.2 deaths to 82.9/100,000 inhabitants (75.6% increase) (Fig. 2). In 1990, it caused 6.1% of deaths, while in 2019, it corresponded to 15.7% of the total deaths registered. Between 1998 and 2019, the rate for men and women practically doubled, reaching 84.3 and 81.5, respectively[16,17].

Pattern and pace of growth of mortality were due to T2DM by state in Mexico from 2000 to 2019 and socioeconomic indicators.

In the year 2000, the highest mortality was concentrated in the central, Bajío, and North-east areas of the country and in Mexico City with 74.5 deaths/100,000 inhabitants, in contrast to Quintana Roo where a rate of 16 was recorded. In 2019, an increase was observed in South-east entities such as Veracruz, Tabasco, and Oaxaca, as well as Puebla, Tlaxcala, Morelos and Mexico (Fig. 3).

The growth rate ranged from 16.0% in Sonora to 236.0% in Quintana Roo, the latter with an accelerated growth rate. Within the G1, there were entities with low mortality in both years, such as Quintana Roo and Sinaloa. In the G2 were Tabasco and Oaxaca, which went from position 25 and 28 in 2000 to first and tenth place in mortality in 2019, respectively. In the G3 were located entities that went from high to low mortality such as Querétaro and Jalisco. Finally, in the G4, Mexico City, Veracruz and Puebla stood out, which were among the 10 entities with the highest mortality in both years. Some G2 entities, which were characterized by a very accelerated growth in mortality, in 2020 showed a low HDI (0.759 or less)[19], with a Gini coefficient of IDH[20] above the national average and a GDP per capita lower than the national average[21] (Table 1).

In other G4 entities such as Mexico City and several in the north-east of the territory, mortality grew at a low rate and the HDI was higher than the national average, its Gini coefficient was below the national average, which reflects lower inequality and its GDP per capita above the national average with the exception of Nayarit and Tamaulipas.

Table 1. Entities with an accelerated rate of growth in mortality and prevalence of type 2 diabetes mellitus, socioeconomic indicators, poverty and social deprivation. Mexico 2020

Mortality growth > 150%	IDH* 2020 Below the national (0.756)	Gini** 2020 Above the national average (0.449)	PIB*** 2019 Lower than the national average (3.8)
G1 Quintana Roo 236.8% G2 Campeche 168.5% G2 Tabasco 189% G2 Guerrero 185%, G2 Oaxaca 167%, G2 Chiapas 154.4%	Quintana Roo, Campeche, Guerrero, Oaxaca, and Chiapas	Campeche, Guerrero, Oaxaca, and Chiapas	Quintana Roo, Guerrero, Oaxaca, and Chiapas
Prevalence Growth > 110.0%			
Oaxaca 219.5% Campeche 205.9% San Luis Potosí 162% Chiapas 145% Tabasco 140.6% Zacatecas 137.6% Hidalgo 135% Veracruz 125% Guerrero 110.8%	Oaxaca, Campeche, Chiapas, Hidalgo, Veracruz, and Guerrero	Oaxaca, Campeche, Chiapas, and Guerrero	Chiapas, Guerrero, Hidalgo, and Oaxaca
Extreme poverty 2020[a]	Food insecurity 2020[b]	Income below the extreme poverty line by income 2020[c]	Educational lag[d]
Chiapas, Guerrero, and Oaxaca	Tabasco, Guerrero, and Oaxaca	Veracruz, Morelos, Chiapas, Guerrero, Oaxaca, Quintana Roo, Campeche, and Tabasco	Chiapas, Oaxaca, Veracruz, and Guerrero

*HDI: human development index. Summary measure composed of life expectancy, education and GDP.
**Gini. Coefficient that measures inequality, the closer it is to 1, the greater the concentration of income and the greater the inequality.
***GDP: gross domestic product. It is the standard measure of the value added created by the production of goods and services in a country during a given period. Maximum value 1, the closer it is to 1, the higher the level of development.
[a]Extreme poverty 2020. Population that has three or more deprivations, out of six possible, within the Social Deprivation Index and that, in addition, is below the minimum well-being line.
[b]Food insecurity 2020. Moderate or severe food insecurity, or population that presented a limitation in the frequency of food consumption.
[c]Income below the extreme poverty line by income. Population that cannot access a basic food basket.
[d]Educational lag. Population aged 18 years and over had a secondary education level or less.

Social determinants and T2DM

A correlation analysis was performed between the variation in mortality (r = 0.78) and prevalence of diabetes (r = 0.53) and the percentage of the population in extreme poverty. The association was positive and significant, that is, the higher the level of extreme poverty in the states, the higher the growth rate of both indicators (Figs. 4 and 5). In 2020, states with accelerated growth rates in mortality and prevalence of T2D (RACMP T2DM) were in a situation of extreme poverty, had insufficient income to have a healthy diet, with a moderate or severe degree of food insecurity, or had a limitation in the frequency of food consumption. They had an income below the extreme poverty line and showed high values in terms of educational backwardness (Table 1 and Fig. 6).

Discussion

The increase in the prevalence and mortality of T2DM is a structural health problem caused by a combination of various SDCs, which have not been addressed in a conclusive manner. In the country, in 2020, the percentage of the population in extreme poverty was 8.5%, which implies that one in almost 12 people in Mexico had an insufficient income to have adequate food. Likewise, in 2020, around 28.6 million people had a moderate or severe degree of food insecurity, or had a limitation in the frequency of food consumption[21]. Income, expenditure and access to food can be observed through the percentage of the population that has an income below the extreme poverty line, in 2020, this was 17.2%, which implies that two out of almost 10 people could not access a basic food basket.

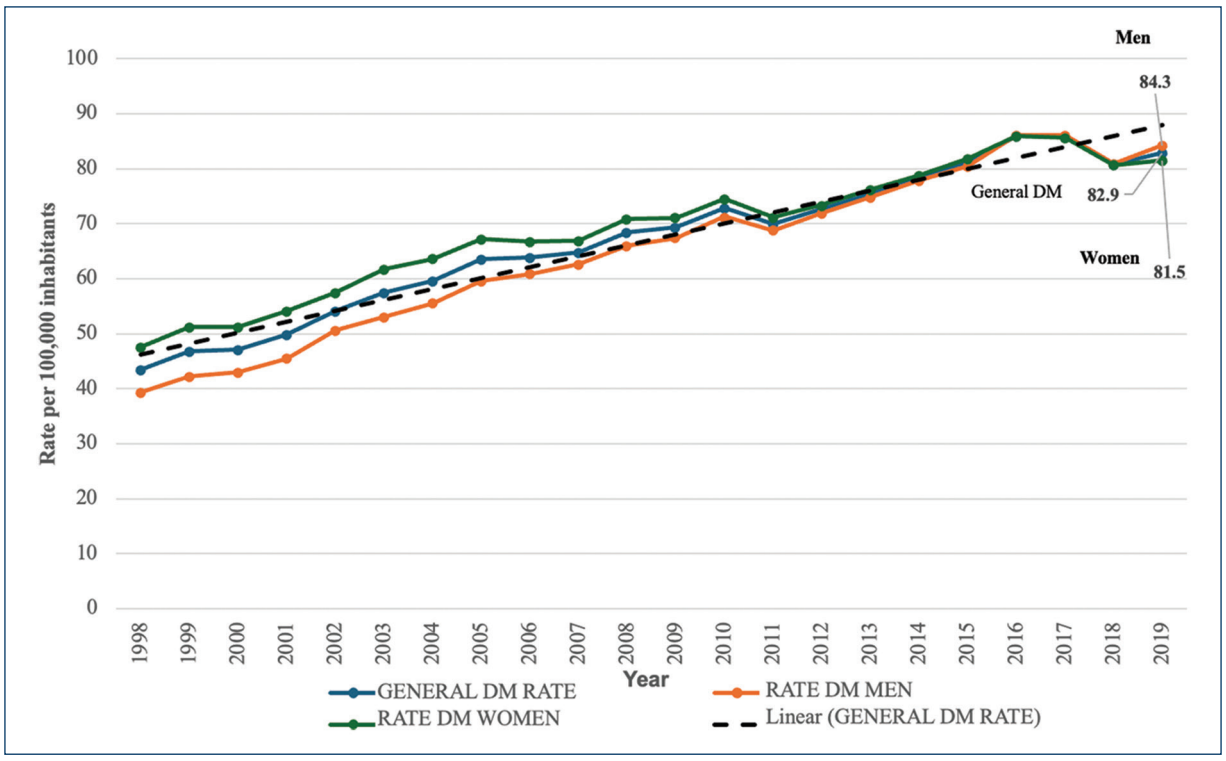

Figure 2. Mortality rate for diabetes mellitus (E10-E14) in Mexico by sex, year 1998-2019
(prepared by the author with information from National Institute of Statistics and Geography. Mortality statistics, 1998 to 2019. CONAPO: Population Projections, 1990-2010 and 2010-2030. Rate per 100,000 inhabitants).

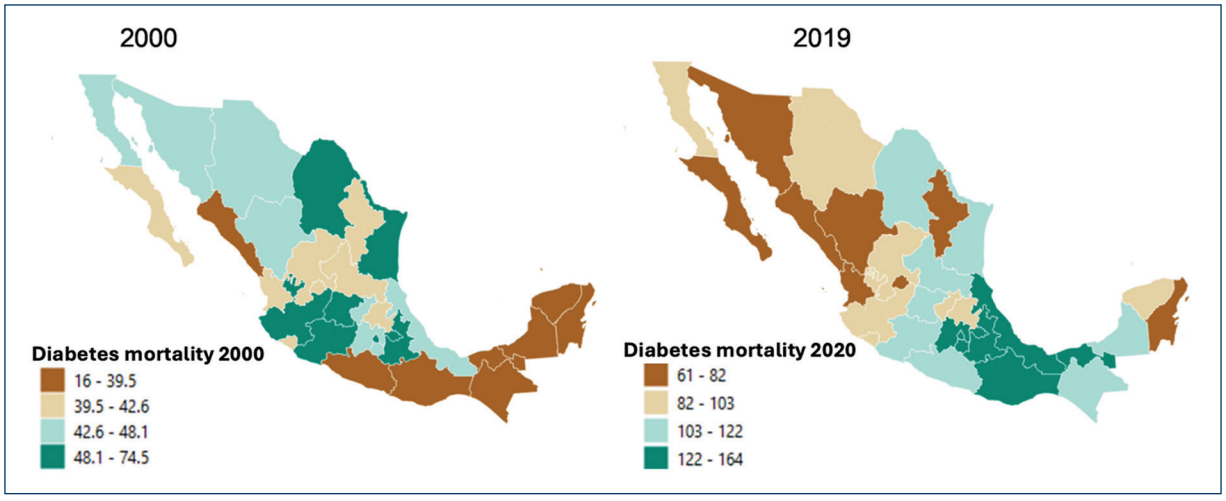

Figure 3. Mexico: diabetes mellitus mortality rate per 100,000 inhabitants 2000-2019
(authors' elaboration based on data from the National Institute of Statistics and Geography death registry and CONAPO population projections).

Another related social determinant is education, in the country, the literacy rate in people aged 15 years and over, in 2020, it was 95.2% and 54.9% of the population aged 18 and over had a secondary education level or less[23]. At the national level, in this year, the educational lag was 19.2%.

The heterogeneous increase in mortality and prevalence of T2DM among the entities is related to their

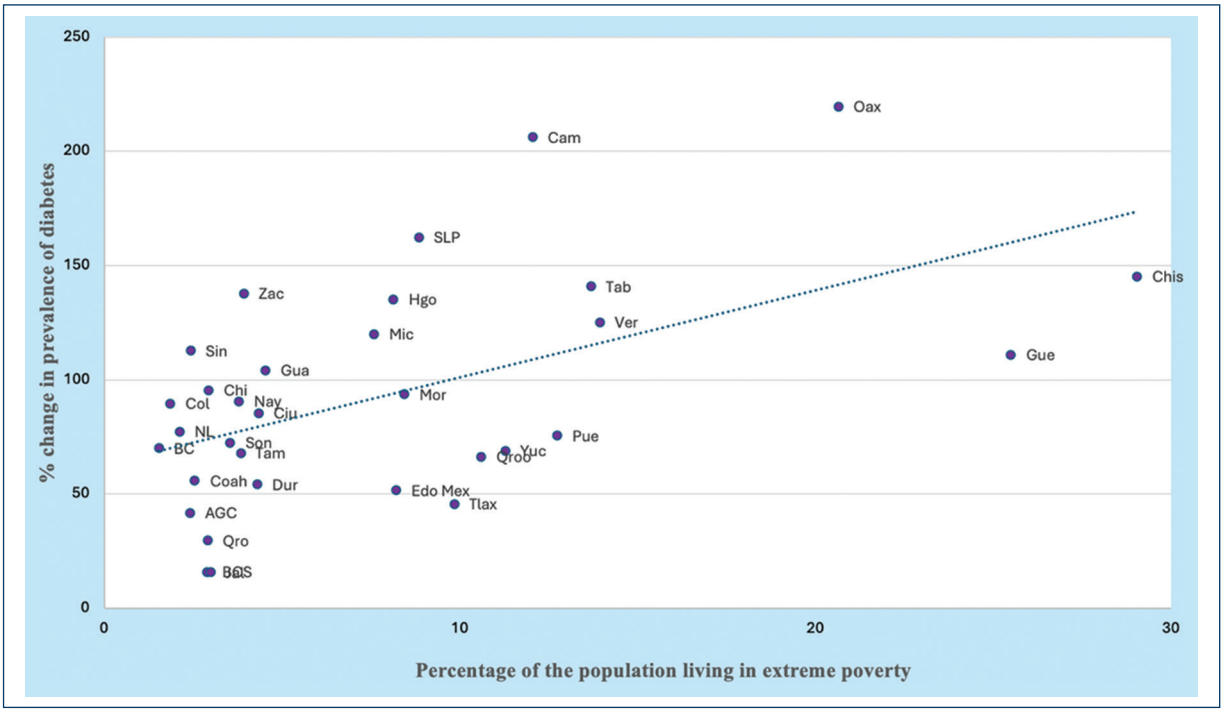

Figure 4. Correlation between the rate of change in the prevalence of type 2 diabetes mellitus (2000-2018) with the percentage of the population in extreme poverty in 2020
(authors' elaboration based on poverty data from CONEVAL and ENSANUT 2018 from the National Institute of Public Health).

socioeconomic differences. The southeastern states such as Chiapas, Oaxaca, Guerrero, Quintana Roo stand out, which showed the highest growth rates in both indicators. More than 50% of its population was in high conditions of food insecurity, in addition to lack of access to nutritious and quality food. In states such as Campeche and Tabasco, it is striking that the impact of oil activity is not reflected in the population.

In the above context, it is notorious that, according to the ENSANUT 2021[22], there are more people who are unaware that they have T2DM than those who already have an established diagnosis, representing, together with people who are already sick, a quarter of the population aged 20 years and over. It is evident that in Mexico there is an insufficient health system in terms of the timely detection of the disease, and a first level of care that requires resuming strategies such as primary healthcare that contribute to strengthening the prevention of diseases such as diabetes.

On the other hand, for the purposes of this work, the fact of appreciating a different behavior of prevalence than expected in some states (G3) stands out. It should be remembered that the magnitude of this indicator depends on the number of new cases and the duration of the disease[24]. As it is a chronic, non-reversible health problem, the observed decrease in prevalence in the study period would have to be the result of a reduction in the incidence, which implies having acted on the factors that generate it, and, therefore, constitute a success in the preventive programs implemented, or be the effect of a reduction in the duration of the disease, which, in turn, would be the result of higher mortality. Neither of the two possible explanations is satisfactory; therefore, it is necessary to continue analyzing this complex behavior. For example, in Jalisco, mortality from T2DM decreased, but the mechanisms related to this result are unknown.

Poverty was traditionally associated with malnutrition and food shortages. It is currently also linked to obesity, T2DM, and other metabolic diseases[25]. One explanation for the above is that in recent decades a diet based on ultra-processed, energy-dense, low-cost products has been adopted, which has been associated with low

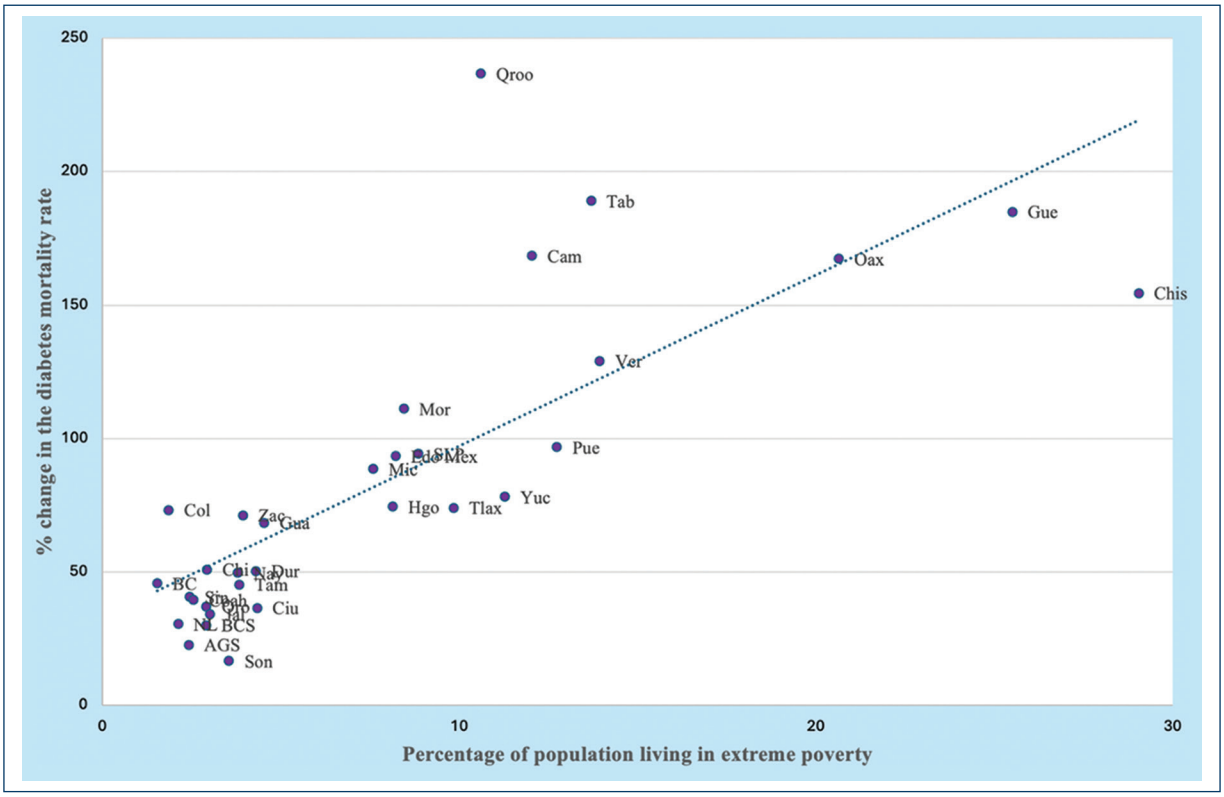

Figure 5. Correlation between the rate of change in mortality due to Type 2 diabetes (2000-2019) and the percentage of the population in extreme poverty in 2020
(authors' elaboration based on poverty data from CONEVAL and the National Institute of Statistics and Geography death registry).

income and poor educational level[26,27], as shown in this study. Adequate levels of income and schooling condition favorable behaviors that translate into seeking preventive care for diseases, as well as the adoption of healthy behaviors[28,29], such as the consumption of an adequate diet, the practice of physical activity, the performance of screening tests, and, if the disease is already present, therapeutic attachment, the execution of glycemic control tests, participation in support groups, among others.

On the other hand, as Laurell[30] points out, the processes of social determination do not act like the classic biological, physical, or chemical agents in the generation of a particular disease, since they do not have an etiological specificity, as Bradford-Hill proposed in his causality criteria[7], nor do they mechanically obey a dose-response relationship. However, several authors, such as Marmot[31] and Krieger[32], have documented the existence of a gradient of mortality and life expectancy with respect to the socioeconomic conditions of the population, using, respectively, concepts such as social class (although it does not strictly correspond to the Marxist notion, from which it comes), and the incorporation of social experiences into the body. That are expressed biologically.

The data observed in the present study regarding the behavior of prevalence and mortality due to T2DM also suggest the existence of this gradient.

Conclusion

Based on the analysis carried out, it is hypothesized that the care of T2DM in Mexico, focused on biological and behavioral factors and pharmacological treatment, has left aside key elements such as DSS, which could contribute to slowing its increase. If the strategy is not modified, this accelerated increase will mainly affect the poorest states and certainly rural areas (which were not analyzed in this study) which, due to their access to health services and living conditions, will have more far-reaching consequences[33].

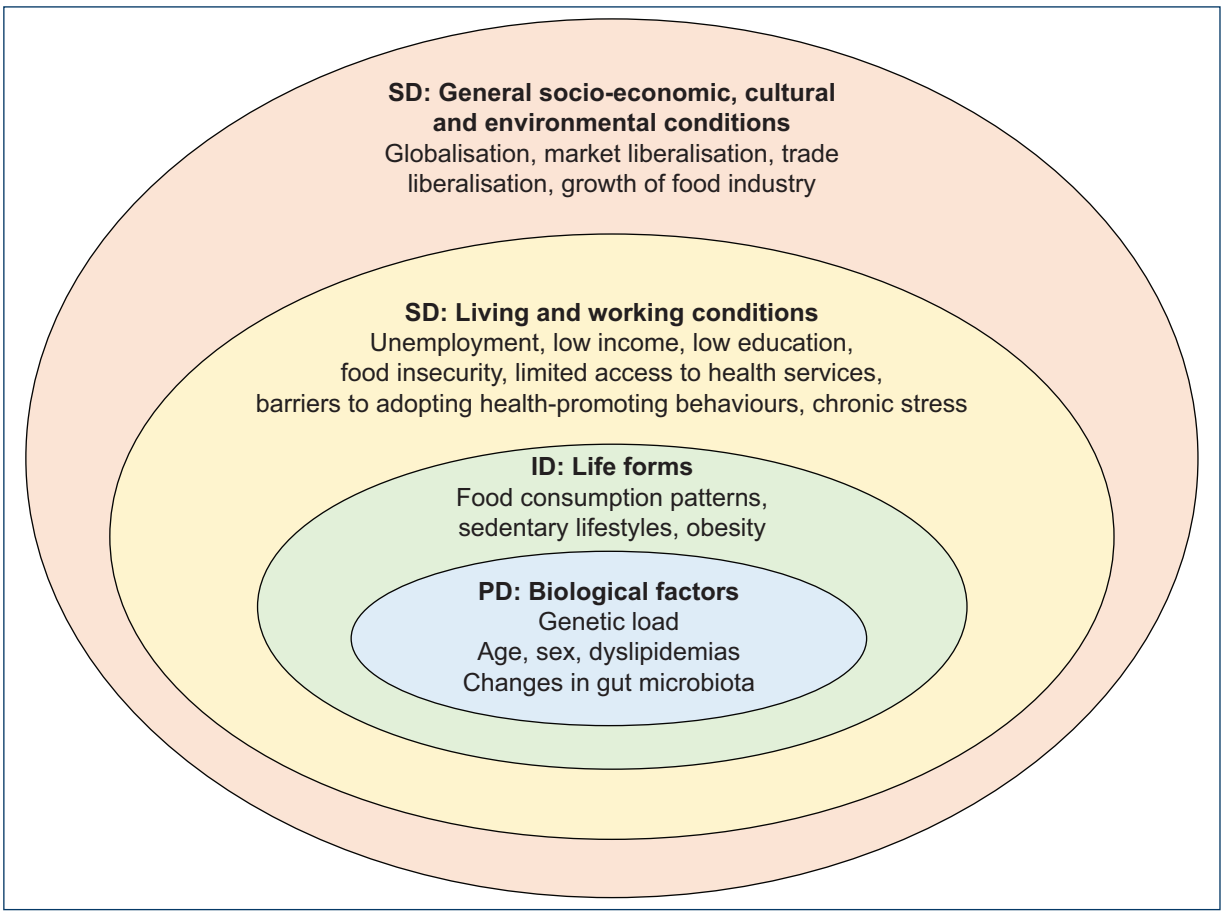

Figure 6. Social determinants of health and Type 2 diabetes mellitus.
SD: structural determinants; ID: intermediate determinants; PD: proximal determinants.

What was observed in this study with respect to the selected socioeconomic indicators raises the need to continue exploring the causal complexity of this disease. The working group is aware of the danger involved in analyzing social conditions and processes as if they were risk factors; however, information is presented that points to the fact that these processes are presented in the case of T2DM. It is not enough to point out the existence of associations, we must move on to the explanation of why they exist. As has been pointed out: the causes of the causes must be sought[30], that is, public policies and specifically health policies must be reanalyzed.

Limitations

The very nature of an ecological study makes it impossible to know the simultaneous distribution, at the individual level, of a condition (or risk factor) with the presence of damage to health.

In this type of study, the magnitude of the association of two sociodemographic variables tends to be greater than in studies that work with individual information, which can give rise to a multicollinearity problem. It should also be remembered that these designs are a very useful tool in Public Health for the generation of hypotheses and for the evaluation of preventive and/or control interventions[13].

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of humans and animals. The authors declare that no experiments involving humans or animals were conducted for this research.

Confidentiality, informed consent, and ethical approval. The authors have obtained approval from the Ethics Committee for the analysis of routinely obtained and anonymized clinical data, so informed consent was not necessary. Relevant guidelines were followed.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

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