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ORIGINAL ARTICLE

Type 2 diabetes: epidemiological changes at Instituto Mexicano del Seguro Social—associated with complications in Mexico

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Abstract

Background Mexico is a country with a high frequency of type 2 diabetes mellitus (DM2). DM-related complications can increase the number of medical appointments and hospitalizations, impact patient quality of life, and exacerbate hospital care costs. The goals of this study were to analyze epidemiological data of DM2 over the last 10 years and to compare its comorbidities and mortality in individuals listed at the Instituto Mexicano del Seguro Social (IMSS) in 2013 and 2015. The database was compiled for doctors, validated by engineers in computer systems, and analyzed by statisticians. E-10-E-14 registered patients with DM2 (based on International Classification of Diseases (ICD-10)) from 2005, 2013, and 2015 were analyzed through the Family Medicine Units and Non-Communicable Diseases Analysis System (SANENT)® databases. Incidence, comorbidity, and mortality were described.

Results We included 29,525,905 individuals, including 3,395,389 DM2 patients, in 2013, and 31,389,711 individuals, including 3,547,006 DM2 patients, in 2015, in the IMSS. The incidences of DM2 in 2005 and 2015 were 124 and 120 per 100,000 IMSS members, respectively, without significant differences. The diabetes complications caused partial disability in 253 and 341 per 100,000 individuals in 2013 and 2015, respectively. Overall mortality decreased from 2005 to 2015 (rates of 594 vs. 350 per 100,000 persons; $p < 0.001$).

Conclusion Though the overall mortality and incidence of DM2 decreased from 2005 to 2015, the complications maintained the same prevalence rates in 2013 and 2015; however, disability complications increased in 2013 and 2015, emphasizing the need for proper control methods acting over this dual axis.

Keywords Type 2 diabetes · Epidemiology · Incidence · Complications · Mortality

Introduction

Diabetes *mellitus* (DM) is a group of chronic diseases characterized by the presence of persistent hyperglycemia and multiple metabolic abnormalities. Type 2 diabetes *mellitus* (DM2) is a subtype of DM characterized by insulin resistance and hyperinsulinism and is often non-insulin-dependent [1, 2]. The number of people with diabetes has increased due to population growth, urbanization, extended life expectancies, an elevated prevalence of obesity, and a lack of physical activity. The prevalence of DM2 is rapidly increasing in both developed and underdeveloped countries [3].

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The urban population in Latin America presents a prevalence of diabetes between 4 and 8%, but this rate is higher in countries or areas with low or middle socioeconomic status as well as in rural areas. The CARMELA study, which was performed in 7 cities in Latin America in 2005, reported that the prevalence of diabetes in Mexico City was 8.9% [4, 5]. In Mexico, according to the National Survey of Health and Nutrition in 2012, there was a significant increase of 10% points in the prevalence of overweight and obesity [6, 7] compared with the prevalence reported in 2000. Concomitant with the increased incidence of obesity among the adult population (aged 20 or older) from 61.8 to 71.3% from 2000 to 2012, the percentage of the adult population with diabetes also increased from 5.7 to 9.1%, which corresponds to an increase of almost 60% [8] and indicates increased morbidity and mortality due to DM2.

DM-related complications can increase the number of medical appointments and hospitalizations, impact patient quality of life, and exacerbate hospital care costs. Macrovascular complications include systemic hypertension, acute myocardial infarction (AMI), congestive heart failure (CHF), cerebrovascular accident (CVA), and peripheral artery disease (PAD). Patients with DM2 are at a 2- to 4-fold increased risk of suffering from either AMI or CVA [9]. Microvascular complications include neuropathy, retinopathy, and nephropathy, which are related to HbA1c levels, as was demonstrated in the UKPDS, but it is now known that the high glycemic variability is also important [10]. This is because HbA1c only analyzes glycemic averages, and the hyper- and hypoglycemic indexes can generate more complications over the long term [11]. One of the most common chronic complications associated with DM is diabetic foot, which is related to extended, inappropriate glycemic control of DM [12].

In Mexico, the Instituto Mexicano del Seguro Social (IMSS) is the health institute that assists the largest percentage of the population [11]. Since 2006, DM screening using capillary blood glucose has been performed in addition to campaigns to detect and prevent obesity and DM [13]. However, there is no updated epidemiological data regarding DM and the changes in the incidence and mortality of DM since the implementation of these prevention campaigns. Therefore, the objectives of this study are to compare the incidence, prevalence, morbidity, chronic complications, and disability in active workers among the Mexican population who were included in the IMSS in the years 2013 and 2015 and to compare the incidence and mortality of DM2 in 2005 and 2015.

Materials and methods

This was a cross-sectional study. The patients were clinically diagnosed by doctors at the IMSS. The data used in this study were obtained from the Non-Communicable Diseases Analysis System (SANENT)® and the databases of Family Medicine Units. At the IMSS, medical attention is classified as three levels: 1st level facilities perform preventive measures and treat acute and chronic pathologies without complications; 2nd level facilities address complicated pathologies, chirurgic interventions, and treatments that require hospitalization; and 3rd level facilities are equipped to treat individuals with complex and complicated diseases. The SANENT database contains information for every enrolled patient and for individuals who attended regular medical appointments at the IMSS. Diseases are classified using codes from the International Classification of Diseases (ICD-10).

The data to compose the database were compiled for doctors who attend and diagnose patients attending the hospitals affiliated with the IMSS; the data are validated by a team of engineers in computer systems and are analyzed by statisticians affiliated with specialized centers strategically located at regional and state levels.

For this study, information collected from patients aged 20 years or older (as of 2005, 2013, and 2015) was described using the following ICD-10 codes: E10 (insulin-dependent diabetes mellitus), E11 (non-insulin-dependent diabetes mellitus), E12 (malnutrition-related diabetes mellitus), E13 (other specified diabetes mellitus), and E14 (unspecified diabetes mellitus) [14].

Among all the patients with DM2 who were enrolled in the IMSS, active workers with partial disability due to DM2 were described (as of years 2013 and 2015), and individuals with major amputations of lower extremities were also included and described. The latter group was identified using the ICD-9 codes 8415-8419, and those who required amputation due to traumatic causes were excluded (CIE-10: S77, S78, S87, S88, S98, T053, T055, and T136). Based on the extracted partial disability cases, the partial disability rate out of every 100,000 active workers who were enrolled in IMSS was calculated. The prevalence of disease, number of new DM2 cases, and deaths were also calculated. The death rate per 100,000 DM2 patients by city and age group was estimated.

From the data encompassing all the enrolled patients, the data of those who attended regular medical appointments at first-, second-, and third-level care medical units were analyzed. It was considered that these patients had relatively appropriate control of their diabetes by measuring their fasting blood glucose levels, which should remain in a range of 70–130 mg/dl. Appropriate control of blood pressure was also defined as systolic blood pressure between 100 and 130 mmHg and diastolic blood pressure between 60 and 80 mmHg. The body mass index (BMI) was calculated using the somatometric variables of patients (e.g., weight and height), and obesity was classified as a BMI > 30 kg/m^2.

Among the DM2 patients who attended their regular medical appointments (as of years 2013 and 2015), complications due to DM2 were included based on the ICD-10 classification with the codes E-10-E-14; these complications include

disruptions in the following systems: peripheral circulation, kidney, ophthalmic, cerebrovascular, and ischemic heart. The number of registered cases with these codes was analyzed.

Mortality analysis included causes of death using the following ICD-10 codes: E10 (insulin-dependent diabetes mellitus), E11 (non-insulin-dependent diabetes mellitus), E12 (malnutrition-related diabetes mellitus), E13 (other specified diabetes mellitus), and E14 (unspecified diabetes mellitus) in years 2005 and 2015.

Statistical analyses

The media and standard deviations of quantitative variables and the ratios of the qualitative variables were calculated. To calculate the incidence, global mortality, and mortality by city and age in 2005, 2010, and 2015, p values were calculated using the chi-square test. A p value < 0.05 was considered statistically significant. SPSS v.17.0 was used for the statistical analyses.

According to the Helsinki Declaration, the protocol was evaluated and approved by the National Research and Health Ethics Committee of IMSS with registry number R-2014-785-024.

Results

Prevalence of DM2

In 2013, among 29,525,905 people registered in the IMSS, 3,395,389 patients had DM2 (prevalence of 11.4%), with an incidence of 3.8% ($n = 129,186$). For 2015, among 31,389,711 people registered in the IMSS, 3,547,006 patients with a record of DM2 according to ICD-10 codes were included; this corresponds to a prevalence of 11.3% within the studied population. The incidence of DM2 was 3.128% ($n = 110,983$), and females were predominant among patients (59.8%; $n = 2,121,109$).

Demographic and clinical characteristics of subjects with DM2

In 2013, among the 3,395,389 patients with DM2, only 1,017,360 (29.9%) attended regular medical appointments at first- and second-level care facilities. Control parameters showed that less than half of the patients had an appropriate fasting blood glucose level (44.3% $n = 450,984$), and appropriate hypertension control was observed in approximately 79.5% ($n = 809,667$) (Table 1).

For 2015, among the 3,547,006 patients with DM2, only 69.2% ($n = 2,453,795$) attended regular medical appointments at first- and second-level care facilities. The analysis of the results in this year based on the control parameters showed that almost half of the patients had an appropriate fasting blood glucose level (57.5%) and that 42.73% ($n = 1,048,600$) were obese. Appropriate hypertension control was observed in approximately 80% of the patients (Table 1).

DM2-associated chronic complications

The chronic complications were identified in 59,819 patients in 2013 and in 62,005 patients by 2015. When comparing the complication rates per 100,000 patients in 2013 and 2015, there were no significant differences. The most frequently observed complications involved the kidney (rates of 513 and 517 per 100,000 in 2013 and 2015, respectively) followed by ischemic heart disease (rates of 496 and 469 per 100,000 in 2013 and 2015, respectively) (Fig. 1).

Complications that cause partial disability in active workers for regions

In 2013, among all patients with DM2, 33.42% ($n = 1,134,886$) were registered as active workers. Within this subgroup, the presence of complications that caused partial disability totaled 2882 cases, which correspond to a rate of 253 cases per 100,000 workers nationwide. For 2015, among all patients with DM2, 39.76% ($n = 1,410,442$) were registered as active workers; the presence of complications that caused partial disability increased to 4822 cases, which correspond to a rate of 341 cases per 100,000 workers nationwide.

The state of Coahuila was identified as having the highest rate, with 827 cases per 100,000 workers, followed by the states of San Luis Potosí, Tabasco, Sinaloa, Chihuahua, Baja California Sur, and Tamaulipas, with rates between 480 to 423 cases per 100,000 workers. Among all the patients registered with a partial disability, 95% ($n = 4584$) were due to major amputation of a lower extremity. According to the data identified for 2013, the states of Coahuila and San Luis Potosí also had the highest rates of disability cases.

Comparison of the incidence and mortality rates of DM2

As shown in Fig. 2a, the incidence rates of DM2 in 2005 and 2015 were 124.8 and 120.7 per 100,000 people enrolled in IMSS, respectively, without statistical significance. In addition, global mortality also presented a decrease when comparing the rate in 2015 to that in 2005 (594 vs. 350 per 100,000 people in 2005 and 2015, respectively, $p < 0.001$) (Fig. 2a). However, when the mortality rates from 2005 and 2015 were stratified by age group, there were significant decreases in mortality rate in the age groups ranging from 55 to 79 years and from 35 to 79 years ($p < 0.001$) (Fig. 2b).

Table 1 General characteristics of patients registered with type 2 diabetes mellitus

·	Year 2013 *n* = 1,017,360 Media ± standard deviation	Year 2015 *n* = 2,453,795
Demographic characteristics		
Age	*62.3 ± 12.8*	*60.1 ± 13.2*
Sex female[a]	*622,624 (61.2)*	1,428,108 (58.2)
Clinical measurements		
Fasting blood glucose (mg/dl)	136.1 ± 69.8	142.2 ± 79.2
Systolic blood pressure (mmHg)	121.7 ± 12.4	122.2 ± 13.7
Diastolic blood pressure (mmHg)	76.9 ± 8.1	76.4 ± 8.4
Body mass index (kg/m^2)	28.6 ± 5.2	29.7 ± 5.5
Control parameters		
Appropriate fasting blood glucose level[a]	450,984 (44.3)	1,410,932 (57.5)
Appropriate hypertension control[a]	809,667 (79.5)	1,965,489 (80.1)
Obesity[a]	393,718 (38.7)	1,048,600 (42.73)

[a] Frequency (%)

The states with a DM2 population greater than 200,000 individuals correspond to the most populated cities in the country, including Mexico City, the State of Mexico, Jalisco, and Nuevo León. These cities correspond to the most important in Mexico and comprise almost 40% of all patients; the northern and southern states, where fewer than 50,000 patients with DM2 live, comprise the second and third largest concentrations of individuals with DM2.

A total of 22,516 DM2-related deaths were recorded in 2015, which correspond to a mortality rate of 120.7 per 100,000 people enrolled in the IMSS. According to the geographical distribution, cities with a higher mortality rate do not correspond to the cities with the highest percentage of patients with DM2. For instance, the southern states have less than 100,000 patients registered with DM2, but the mortality rate is greater than 150 per 100,000 people. The mortality rate was lowest in most of the northern states of the country (Fig. 3).

Discussion

In our study, we investigated the epidemiological data of patients with DM2 in the IMSS from Mexico, and the prevalence was 11.3%; however, only half of registered patients with DM2 attended regular medical appointments. Approximately half of the patients had an appropriate fasting blood glucose level, and chronic complications were present in 20.8%. Additionally, the incidence and mortality rates in 2015 had decreased compared with those in 2005.

The National Survey of Health and Nutrition 2012 (ENSANUT) reported a national prevalence of DM2 at 9.1%. However, there is a high percentage of the population which does not know they are diabetic [11]. Based on our report, the prevalence rates in 2013 and 2015 were 11.4% and 11.3%, respectively, which are higher than the rates observed in the previous report. ENSANUT [11] is a survey conducted throughout the general population, whereas our

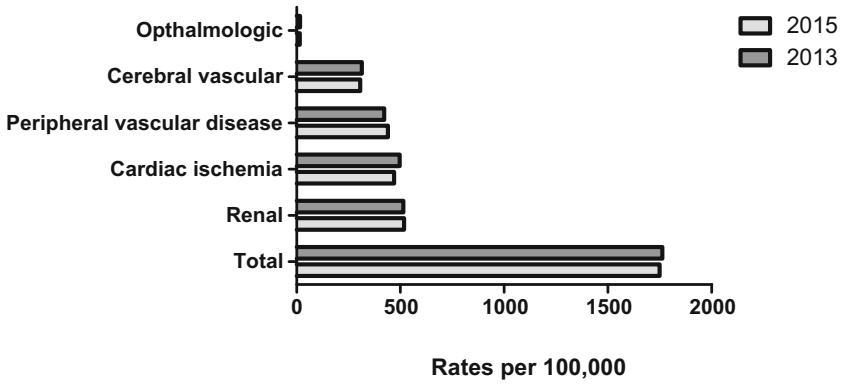
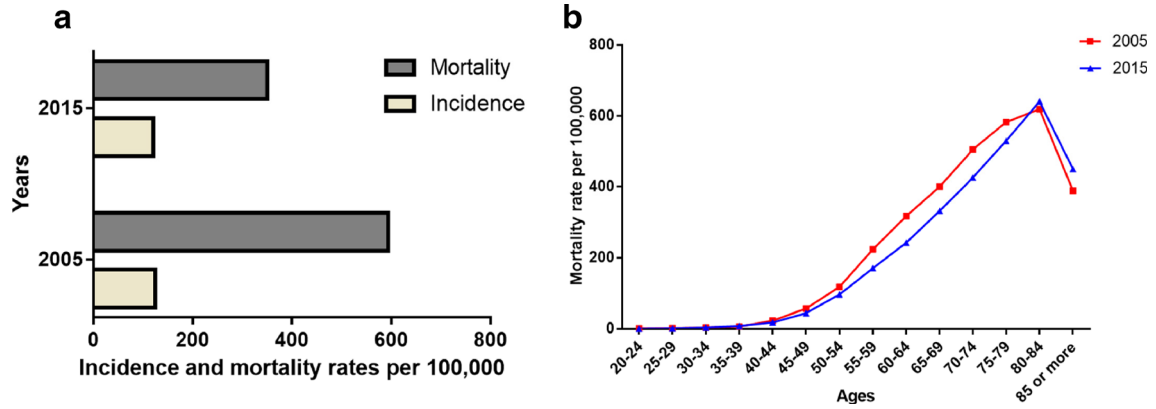


Fig. 1 Patients with DM2 and complications in based on the SANENT record in 2013 and 2015



a) Comparison of the global incidence and mortality of DM2

b) Comparison of the mortality rate of DM2 in 2005 and 2015 by age group

Fig. 2 Comparison of the global incidence and mortality of DM2 and the mortality rate of DM2 by age group in 2005 and 2015. **a** Comparison of the global incidence and mortality of DM2. **b** Comparison of the mortality rate of DM2 in 2005 and 2015 by age group

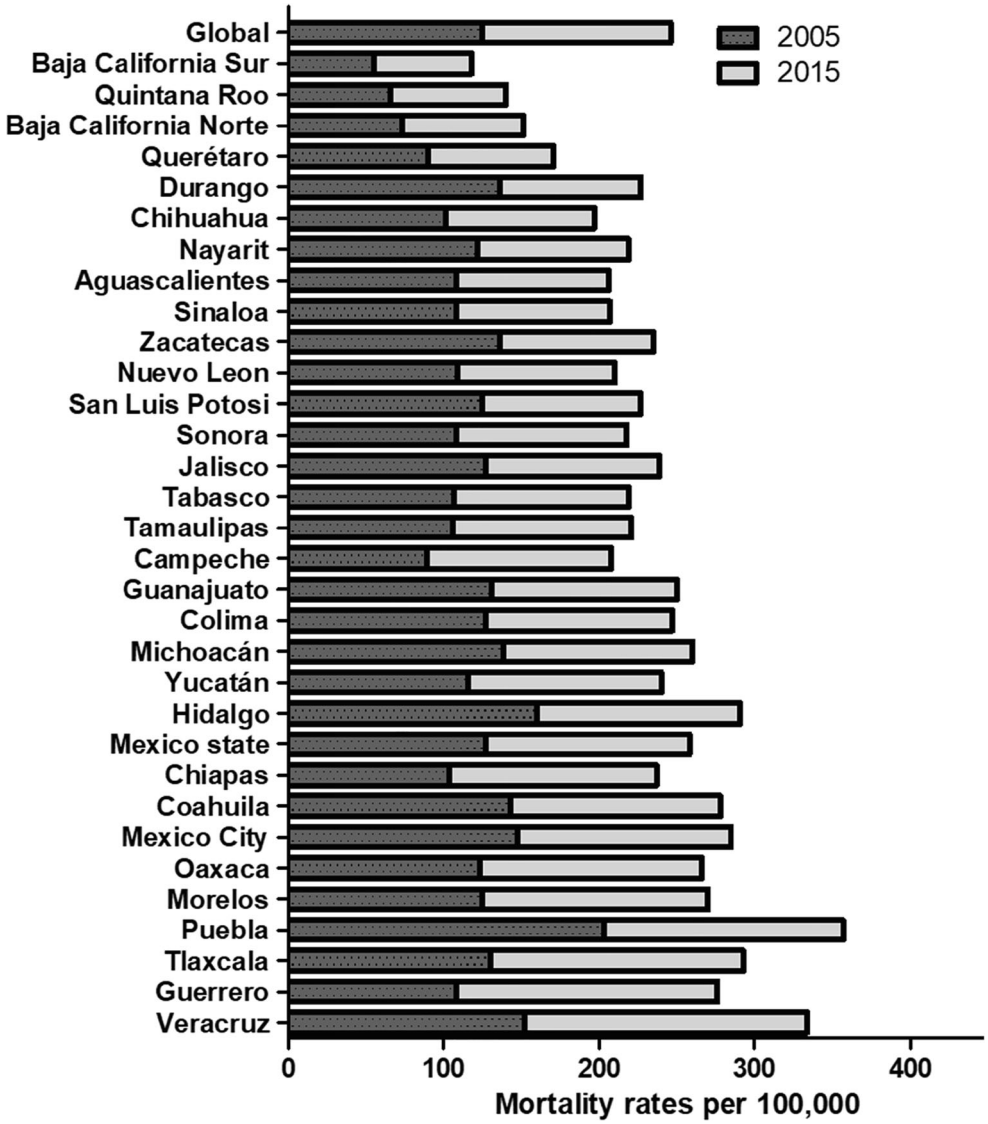


Fig. 3 Mortality rate in 2005 and 2015 among individuals with DM2

study used data extracted from existing medical records, which produced more reliable results. In recent years, multiple health campaigns have been implemented for the timely detection of chronic diseases, including DM2. When comparing the prevalence of DM2 with that in other countries where DM2 is considered one of the primary public health problems, the prevalence is similar; for instance, the prevalence in Korea was 11% in 2013 [15].

By analyzing the incidence calculated in 2015 and comparing it to reports from 10 years ago, there was an observed increase over time. This increase is likely attributed to the timely detection of the disease due to health campaigns initiated in 2006 [13]. In China, an incidence of 15.8 per 1000 person-years [16] was reported between 2006 and 2010. In 2015, we found a rate of 120 per 100,000 subjects, which is higher in our population, and a similar rate was maintained over the last 10 years.

In a study testing the safety of two medications, the prevalence of obesity was also analyzed. The average BMI in the cohort of 9340 patients was 32.5 ± 6.3 kg/m^2, and only 9.1% of the patients had a BMI < 25 kg/m^2. Although there is a higher prevalence of overweight and obesity among individuals with DM2, selection bias can arise, and this should not be taken as a representative sample of patients with DM2 [17]. According to ENSANUT 2012, Mexican individuals aged 20 years or older had a prevalence of either overweight or obesity of 71.3%, which is slightly lower than that observed in our population (42.73% with obesity) however as patients with DM2, are expected to have a higher prevalence of this condition [18]. Nonetheless, a significant increase in the medical care coverage of patients with DM2 between 2013 and 2015 was observed (from 29.9 to 69.2%), which emphasizes the favorable results of health campaigns for sensitizing patients to receiving appropriate medical attention and avoiding chronic complications. Although this is an encouraging start, it is necessary to continue to encourage continued medical care and lifestyle modifications, regardless of whether increased coverage is significant; indeed, for subjects controlled through fasting glucose, an increase of only 44.3 to 57.3% was observed from 2013 to 2015. However, this result does not indicate that the glycemic control was adequate because we could not evaluate these patients with HbA1c; this parameter is important to confirm regarding this issue and represents a weakness in our study.

The decrease in the mortality rate reflects the effects of the medical care that has been implemented in the past decade. This is due to the prevention of severe complications and the early detection of chronic complications as well as the implementation of timely treatments to delay DM2 progression. Specifically, the decrease in mortality rate in individuals between the ages of 40 and 70 can be translated into increased availability, access, and quality of medical care. The availability of alternatives that can replace damaged renal function has led to lower mortality rates and higher survival of renal patients. Although we have observed an improvement in recent years, it has not been sufficient. The mortality rate in Mexico is higher than that in other countries; for instance, Taiwan [19] has a mortality rate of 77.8 (1000 person-year) for people older than 75 years of age, Korea [20] has a mortality rate ranging from 14 to 104 for people aged 50 to 79 years old, and the global mortality rate was 238 (1000 person-years). However, the mortality rate in Mexico ranged from 96 to 529, with a global rate of 350 (per 100,000 people).

The northern states of Mexico receive higher income than those registered in the central and southern states, coinciding with a higher degree of development and higher rates of schooling performance; this is because the northern area has a concentration of industries with the best salaries in Mexico. With better salary and education, patients have better control of their DM2; consequently, the northern states of the country had lower mortality rates [21].

Mexico is a country with a high frequency of DM, and according to our results, the annual incidence of this disease has not changed in the last 10 years. Although health programs have been aimed at detecting DM2 and preventing its complications, these efforts have not been sufficient and require a rethinking of the strategy to promote preventive measures from childhood, since a child with obesity and a sedentary lifestyle has a high probability of having DM with complications in adulthood.

Despite the limitations of this study (i.e., the extracted data were based on secondary sources and glycemic control was determined using fasting plasma glucose levels), this epidemiological study encompasses one of the largest cohorts to date. These data support the notion that the results accurately reflect the current conditions of this pathology in a country whose population is highly prone to suffering from DM2.

With increased awareness of DM2, both demand and costs due to hospitalization and medical care will likely increase. Strict metabolic control is still the best preventive measure to decrease or (at least) delay the development of chronic complications, which will consequently reduce the demand of hospital care. However, effective measures to prevent the occurrence of DM2 would be ideal under these circumstances.

The results of this study support research on multidisciplinary interventions aimed at vulnerable populations, where salaries and education levels are low and the mortality rate due to DM is high.

Conclusions

We conclude that despite identifying a decrease in overall mortality and in the incidence of DM2 from 2005 to 2015, complications maintained the same prevalence rate in 2015 and 2013, while disability complications increased. Our study also shows a higher prevalence of obesity in females than in

males, and complications involved the kidney and ischemic heart disease, which might be due to various lifestyle and environmental factors, as Mexico is a developing country, and the majority of the population live with limitations, including an absence of medical appointments, which would enable better control of their diabetes; furthermore, many cannot afford adequate treatment, medicine, and healthy food.

Perspective

Future research studies are needed on clinical practices in different regions to clarify the perceived reasons for the control and optimal medical treatment of patients with DM2 in the IMSS, which could result in a decrease in their chronic complications.

Author's contribution All authors (Jessie N. Zurita-Cruz, Leticia Manuel-Apolinar, María Luisa Arellano-Flores, Alejandro Gutierrez-Gonzalez, Aleida de Jesus Rivera Hernandez, Rosa Angelica Carranza-Muleiro, Victor Hugo Borja-Aburto, Nelly Cisneros-González) made substantial contributions to the study design, acquisition, analysis or interpretation of data, and writing of the article, critically reviewing it for important intellectual content or final approval of the version to be published.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Research involving human participants and/or animals According to the Helsinki Declaration, this protocol was evaluated and approved by the National Research and Health Ethics Committee of IMSS, with the registry number R-2014-785-024.

Informed consent The data were analyzed from a database, so authorization was requested from National Research and Health Ethics Committee of IMSS, with the registry number R-2014-785-024.

Abbreviations DM2, type 2 diabetes *mellitus*; ICD-10, International Classification of Diseases; AMI, acute myocardial infarction; CHF, congestive heart failure; CVA, cerebrovascular accident; PAD, peripheral artery disease; HbA1c, glycosylated hemoglobin; IMSS, Instituto Mexicano del Seguro Social; SANENT, Non-Communicable Diseases Analysis System; BMI, body mass index

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