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Mortality from type 2 diabetes and implementation of the PREVENIMSS program: a time series study in Mexico, 1998-2015

Mortalidad por diabetes tipo 2 y la implementación del programa PREVENIMSS: un estudio de series de tiempo en México, 1998-2015

Mortalidade por diabetes tipo 2 e implementação do programa PREVENIMSS: um estudo de série temporal no México, 1998-2015

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Abstract

Type 2 diabetes is the leading cause of morbidity and mortality in the world. In Mexico it is the first cause of mortality, disability, and potential years of life lost due to premature death. The Mexican Institute of Social Security (IMSS) implemented the PREVENIMSS strategy. The aim of the current study was to estimate the program's effect on the mortality trend from type 2 diabetes, based on an interrupted time series analysis. At the beginning of the target period, the diabetes mortality rate was higher in IMSS beneficiaries than in the control population. After the program's implementation, there was a slight reduction in the mortality trend, while the control group showed an upward trend. Differences in the trends between the two groups suggest that they are not the exclusive result of institutional interventions. Living and work conditions could explain these differences.

Diabetes Mellitus; Mortality; Time Series Studies

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Introduction

Non-communicable diseases are one of the most serious health challenges in the 21st century, and national development requires measures to avoid their expansion [1].

To deal with this challenge, the World Action Plan for the Prevention and Control of Non-Communicable Diseases was launched for 2013-2020, emphasizing the need for progress in the health system, reoriented and strengthened to improve early detection of persons with non-communicable diseases in order to avoid complications, reduce the need for hospitalizations and complex interventions, and prevent premature death [2].

Type 2 diabetes is the leading global cause of mortality and morbidity, affecting 285 to 347 million people in the world. Global prevalence of diabetes in 2014 was 10% and is expected to continue to increase [1,2,3].

In Mexico, type 2 diabetes is the leading cause of mortality, years of life lost due to premature death, years with disability, and years of healthy life lost [4]. Prevalence of diagnosed diabetes in Mexico increased from 7% to 8.9% from 2006 to 2012 and increased with age, reaching its peak between 65 and 68 years. According to estimates, the incidence of diagnosed diabetes increased exponentially from 1960 to 2012. The projected rates in various incidence-by-age scenario suggest that prevalence of diabetes in adults may reach 13.7-22.5% by 2050 [5].

Mexico's health system is heterogeneous and fragmented [6]. The public health agencies consist mainly of the Mexican Institute of Social Security (IMSS) and the Institute of State Employees' Social Security and Social Services (ISSSTE), based on a contributive system covering workers in the formal sector, while the agencies provide care to the population without social security like the program IMSS-Oportunidades (IMSS-O) and Popular Health Insurance (SPS). Meanwhile, the private sector consists of service providers working in private offices, clinics, and hospitals, besides purchase of services from insurance companies [7].

In 2002, the IMSS implemented the PREVENIMSS strategy to respond to previously dispersed health measures and the epidemiological transition. A process of improvement in family medicine was implemented, including the Integrated Health Programs strategy, designed in 2001 and launched in 2002, with the acronym PREVENIMSS, merging the concept of prevention with the Institute's initials. The strategy systematically organizes the provision of preventive services in five major programs: Children's Health (up to 10 years of age), Adolescents' Health (10 to 19 years), Women's Health (20 to 59 years), Men's Health (20 to 59 years), and Health of the Elderly (60 and older). The programs' content was based on the magnitude, transcendence, impact, and susceptibility to the harms or risk factors for prevention [8]. The component of PREVENIMSS for the detection of type 2 diabetes aims to identify the change in blood glucose based on a capillary blood sample and reading with a blood glucose meter, timely diagnosis, and prevention of progression and the development of chronic complications. Screening for altered glucose tolerance was done each year at the beginning of the program and currently every three years in the population over 45 years of age, and starting at 20 years in individuals with overweight or obesity and a direct family history of diabetes.

Based on the above, the aim of the current study is to show the effect of the PREVENIMSS program on the mortality trend from type 2 diabetes in the IMSS beneficiary population.

Material and methods

A descriptive study was conducted, based on interrupted time series analysis, both pre-post type for the IMSS beneficiary population as well as pre-post, considering the threat to the internal validity or inferential validity derived from distinct external events in relation to target intervention known as a historical factor in such studies. The factor was controlled by studying and comparing with a control group, consisting of deaths in non-IMSS beneficiaries over 20 of age during the same period analyzed. Definition of type 2 diabetes was based on codes E11-E14 of the International Classification of Diseases, 10th revision. The National Health Information System of the Mexican Health Secretariat (SINAIS) was the source of annual death records from diabetes mellitus from 1998 to 2015 in persons over 20 years of age, according to state of residence and type of health service (Secretaría de Salud. Bas-

es de datos de defunciones generales años 1998 a 2015. http://www.dgis.salud.gob.mx/contenidos/basesdedatos/BD_Cubos_gobmx.html, accessed on Feb/2017).

Importantly, SINAIS is administered by the General Division of Health Information, whose responsibilities defining parameters for death certificates, coordinating the elaboration of guides for exchange of health information, and serving as the official source of health information in Mexico.

The overall mortality rate for beneficiaries of the IMSS was defined as the number of deaths in the total population according to estimates conducted by the National Population Council (CONAPO), per 100,000 inhabitants (Proyecciones de la población 2010-2015. http://www.conapo.gob.mx/es/CONAPO/Proyecciones, accessed on Feb/2017), due to the lack of available information for identifying the IMSS beneficiary population per age group in 1998-2002. A direct adjustment of the mortality rate from type 2 diabetes was performed using Epidat (Xunta de Galicia, Spain; http://dxsp.sergas.es/default.asp).

The R statistical package, version 3.4.2 (The R Foundation for Statistical Computing, Vienna, Austria; http://www.r-project.org), was used for interrupted time series analysis, with 2002 as the reference year for the intervention, considering the initial implementation of the PREVENIMSS program, with the country of Mexico as the unit of analysis.

An ordinary least squares model was performed with the following formula:

$$Outcome_{jt} = \beta_0 + \beta_1 * time_t + \beta_2 * level + \beta_3 * trend_{jt} + \varepsilon_{jt}$$

The Durbin-Watson test was used to identify autocorrelation between the residuals, and a year-adjusted model was performed which identified statistically significant correlation, considering violation of the assumption of independence between the residuals and compromise to the reliability of the results of the model's adjustment [9,10].

Later, we calculated the generalized least squares adjusted for maximum likelihood [10] to identify changes in the historical trend of the disease and following implementation of PREVENIMSS in the beneficiary population. A comparison was performed with a control group consisting of the mortality rate in persons with other types of health services, thus not targeted by the program's activities, using the following formula:

$$Outcome_{jkt} = \beta_0 + \beta_1 * time_t + \beta_2 * group_k + \beta_3 * group_k * time_t + \beta_4 * level_t + \beta_5 * trend_{jt} + \beta_6 * level_{jt} * group_k + \beta_7 * trend_{jt} * group_k + \varepsilon_{jkt}$$

Where β_0 is the baseline result in the control group; β_1 is the preexisting trend in the control group; β_2 is the baseline difference between the control group and the intervention group; β_3 is the preexisting difference in the trend between the control group and the intervention group; β_4 is the level change in the control group; β_5 is the trend change in the control group; β_6 is the difference in the level change between the control group and the intervention group; and β_7 is the slope change from the beginning of the intervention of the second variable of interest.

The hypothetical scenario constructed from the interrupted time series design is initially to identify the "expected" trend if the intervention had not taken place and is called the "counterfactual scenario", that is, the scenario theoretically expected considering the historical trend; this first scenario provides a basis of comparison for the trend following the intervention.

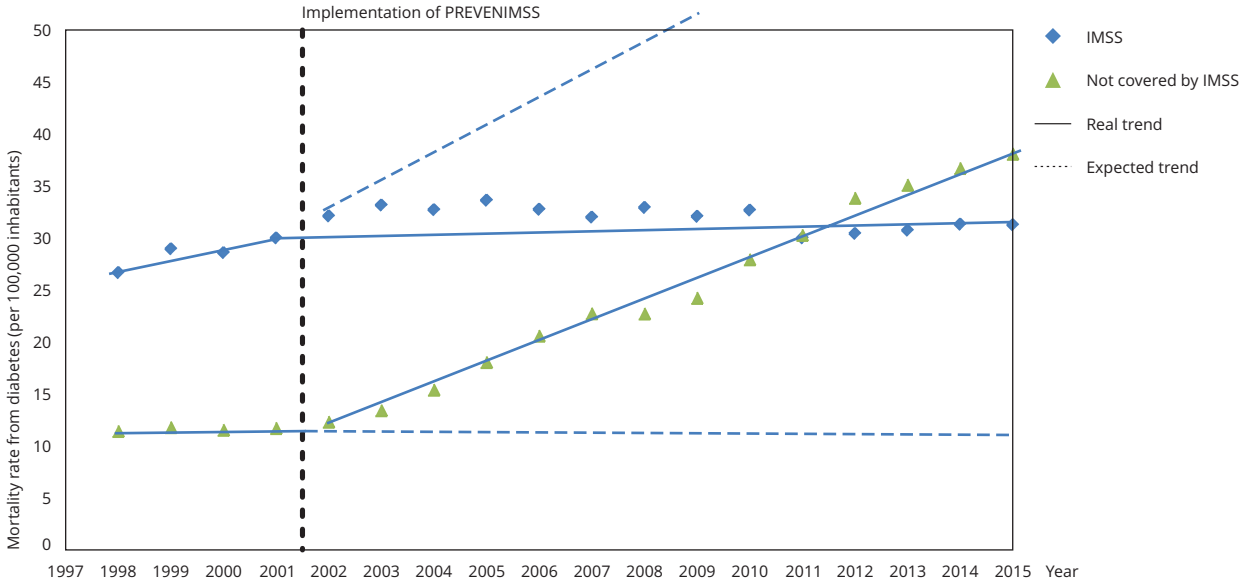
Since the study was based on official sources and did not use private data, it was considered risk-free according to Chapter 1, Article 17 of Mexico's General Law on Health Research.

Results

During the period studied, there were 1,229,877 deaths from diabetes, of which 526,110 were individuals covered by the IMSS. In the year 1998 the mortality rate from type 2 diabetes in the IMSS was higher than in the population not covered by the IMSS (Figure 1). However, in 2015 the diabetes mortality rate was higher in the population not covered (Table 1). The model exclusively analyzing the program's effect on the beneficiary population points to a baseline mortality rate (intercept) of 26.3 per 100,000 beneficiaries; the time value shows an insignificant increase in the monthly mortality rate prior to the intervention ($p = 0.04$), while the level value (mortality rate after the intervention) increased by 4.1 per 100,000 beneficiaries, and the trend later decreased to 1.06 per year (Table 2).

Figure 1

Real and expected mortality trends from diabetes in Mexico, 1998-2015.



IMSS: Mexican Institute of Social Security.

Table 1

Mortality rate (per 100,000 inhabitants) from type 2 diabetes in Mexico, 1998-2015.

Year	IMSS			Non-IMSS		
	Crude rate	Adjusted rate	95%CI	Crude rate	Adjusted rate	95%CI
1998	19.06	26.65	26.65; 26.76	8.15	11.42	11.18; 11.66
1999	21.09	28.95	28.57; 29.36	8.57	11.78	11.53; 12.06
2000	21.20	28.57	28.20; 28.96	8.54	11.52	11.28; 11.76
2001	22.68	30.00	29.60; 30.41	8.82	11.70	11.45; 12.00
2002	24.71	32.09	31.71; 32.49	9.47	12.31	12.04; 12.58
2003	26.03	33.16	32.77; 33.57	10.52	13.41	13.11; 13.48
2004	26.20	32.71	32.31; 32.89	12.31	15.39	15.11; 15.47
2005	27.45	33.61	33.21; 34.00	14.74	18.03	17.77; 18.11
2006	27.28	32.74	32.36; 32.97	17.17	20.58	20.27; 20.88
2007	27.18	31.99	31.61; 32.34	19.32	22.73	22.44; 23.06
2008	28.49	32.92	32.53; 33.29	19.67	22.70	22.41; 22.99
2009	28.29	32.06	31.68; 32.39	21.40	24.20	23.89; 24.53
2010	29.41	32.68	32.34; 32.74	25.18	27.92	27.60; 28.09
2011	27.55	30.00	30.00; 30.32	27.84	30.26	29.91; 30.42
2012	28.53	30.42	30.07; 30.54	31.76	33.83	33.48; 33.99
2013	29.44	30.73	30.43; 31.08	33.63	35.07	34.70; 35.42
2014	30.64	31.31	30.99; 31.47	35.92	36.68	36.35; 36.89
2015	31.26	31.26	30.94; 31.61	38.06	38.06	37.72; 38.40

95%CI: 95% confidence interval; IMSS: Mexican Institute of Social Security.

Table 2

Interrupted time series analysis for mortality from type 2 diabetes.

	Estimated value	95%CI	Standard error	p-value
Intercept	26.25		0.98	< 0.001
Time	0.83		0.37	0.040
Level	4.10		0.69	< 0.001
Trend	-1.06		0.36	0.01
Intercept	8.02	5.8; 10.3	1.15	< 0.001
Time	0.20	-0.6; 1.0	0.42	0.64
IMSS	18.10	14.9; 21.3	1.62	0.000
Time-IMSS	0.77	0.4; 2.3	0.59	0.21
Level	-3.23	-5.1; -1.4	0.95	0.002
Trend	2.08	1.2; 2.9	0.42	< 0.001
Level-IMSS	6.59	4.0; 9.2	1.34	< 0.001
Trend IMSS	-3.23	-4.4; -2.1	0.60	< 0.001

95%CI: 95% confidence interval; IMSS: Mexican Institute of Social Security.

In the mortality analysis of the IMSS beneficiary population, the Durbin Watson test showed a statistically significant negative correlation in time period 3, so it was necessary to shape the adjustment model based on this time period (Table 3).

In the mortality analysis of the beneficiary population compared to the control group (not covered by the IMSS), the results of the Durbin-Watson test did not show correlation (Table 3).

The model built with the control group shows that at the start of the study period, diabetes mortality was higher in IMSS beneficiaries than in controls. The mortality trend from type 2 diabetes after the year in which PREVENIMSS program was implemented showed an increase in the monthly mortality rate of 6.6 deaths per 100,000 inhabitants on average, compared to the change in the mortality trend for the control group ($p < 0.001$), while the mortality trend in IMSS beneficiaries after 2002 showed a mean reduction of 3.6 deaths per 100,000 inhabitants ($p < 0.001$), compared to the control group (Table 2). The historical trend in the control group shows a statistically significant increase ($p < 0.001$) that exceeds that of the IMSS beneficiary population (Figure 1).

Discussion and conclusions

Time series analysis is widely used to assess policies or interventions in various scenarios [11,12,13], including successful applications to evaluate public health programs [12,14,15,16]. The strength of the analysis used with the control group is that the results allow showing the evidence of the effects of health interventions while controlling confounders that could compromise validity [10]. However, one should acknowledge that estimation of mortality rates according to age groups in IMSS beneficiaries in 1998-2002 does not necessarily reflect the real mortality rate.

As for the PREVENIMSS program's effect on diabetes, some authors contend that the reduction in diabetes mortality rates could be explained both by changes in the incidence rates and changes in the case-fatality rates with early detection and treatment as a result of the potential effect of the PREVENIMSS program [17], but there is no hard evidence in this direction. No evaluation of the program exists, and the studies that have been performed focus on identifying immediate changes in individuals' behaviors, but without determining their long-term effects [18,19,20].

The study's results indicate two scenarios in the IMSS beneficiary population. In one, mortality from type 2 diabetes decreased following implementation of PREVENIMSS in relation to the baseline year and modifying the historically upward trend in mortality from diabetes. The second

Table 3

Results of Durbin-Watson test.

Time	Mortality			Mortality with control group		
	Autocorrelation	Durbin-Watson statistics	p-value	Autocorrelation	Durbin-Watson statistics	p-value
1	-0.05	2.06	0.55	0.95	0.05	0.00
2	0.08	1.70	0.44	0.88	0.13	0.00
3	-0.47	2.76	0.05	0.80	0.25	0.00
4	-0.02	1.75	0.95	0.70	0.40	0.00
5	0.08	1.16	0.37	0.59	0.56	0.00
6	-0.17	1.55	0.83	0.46	0.75	0.00
7	-0.07	1.35	0.87	0.33	0.93	0.02
8	-0.27	1.56	0.25	0.20	1.12	0.16
9	0.32	0.37	0.05	0.08	1.31	0.47
10	0.08	0.83	0.96	-0.03	1.50	0.84
11	0.22	0.36	0.25	-0.15	1.67	0.32
12	-0.19	1.16	0.08	-0.25	1.82	0.07

scenario shows a significant contrast with the control group, with a significant increase in mortality. However, the differences between the groups associated with coverage versus non-coverage by the IMSS go beyond the factor targeted by the study, namely the PREVENIMSS strategy. It is necessary to investigate IMSS beneficiaries' specific conditions that distinguish them from non-beneficiaries and that determine health conditions, diet, and social and economic status as they relate to diabetes. The main differences between the two groups feature employment status: while workers covered by the IMSS have formal employment with social and economic benefits, workers without social security generally lack job security and work in informal jobs, underemployment, and part-time or seasonal jobs with no benefits. These differences determine access to services, goods, food, and services that have a differential impact on social groups' health conditions.

Various national strategies have been used to combat overweight, obesity, and diabetes [21,22,23], and the IMSS has launched specific programs under the PREVENIMSS strategy, like DiabetIMSS, despite major weaknesses that limit the follow-up of persons with the disease [24].

In light of the above, studies are needed that address living and work conditions that determine lifestyles in order to explain differences in mortality from type 2 diabetes in the population covered by the IMSS when compared to individuals with access to other health services, with the aim of implementing programs that affect the structural and proximal social determinants of health [25]. Current efforts focusing on lifestyle changes take a prevention-centered approach with individual responsibility [26,27,28], despite evidence that obesity and diabetes require multisector action involving different sectors that contribute to the production, distribution, and marketing of foods while creating an environment that facilitates physical activity [1]. Meanwhile, health systems should join forces with other sectors to ensure that social determinants include the planning and provision of services in each community [2], since there are conditions outside the health system that determine glycemic control in individuals with diabetes [25], thus requiring public policies that guarantee patients' well-being with an inter-sector approach and social justice.

Contributors

O. S. Medina-Gómez contributed to the theoretical development, data collection and analysis, and writing of the paper. I. S. Medina-Reyes contributed to the data collection and analysis.

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Resumen

La diabetes tipo 2 es la principal causa de mortalidad y morbilidad en el mundo. En México es la primera causa de mortalidad, discapacidad, años perdidos por muerte prematura. El Instituto Mexicano del Seguro Social (IMSS) implementó la estrategia PREVENIMSS. El objetivo del presente estudio es determinar el efecto de dicho programa en la tendencia de la mortalidad por diabetes tipo 2, realizando un análisis de series de tiempo interrumpidas. Al inicio del periodo de tiempo analizado, la tasa de mortalidad de diabetes en los derechohabientes era mayor, en comparación con la población control. Posterior a la implementación del programa, se presentó una discreta reducción en la tendencia de la mortalidad, mientras que en el grupo control la tendencia fue ascendente. Las diferencias encontradas en las tendencias entre las poblaciones comparadas sugieren que no son resultado exclusivo de las intervenciones institucionales. Las condiciones de vida y de trabajo podrían explicar dichas diferencias.

Diabetes Mellitus; Mortalidad; Estudios de Series Temporales

Resumo

O diabetes tipo 2 é a primeira causa de morbimortalidade no mundo. No México, é a primeira causa de mortalidade, incapacidade e anos de vida perdidos. O Instituto Mexicano de Seguridade Social (IMSS) implementou a estratégia conhecida como PREVENIMSS. O estudo atual teve como objetivo estimar o efeito do programa sobre a tendência na mortalidade por diabetes tipo 2, com base em uma análise de série temporal ininterrupta. No início do período de estudo, a taxa de mortalidade por diabetes era mais alta entre segurados do IMSS do que na população controle. Depois da implementação do programa, houve uma pequena redução na mortalidade, enquanto o grupo controle mostrava uma tendência crescente. Diferenças nas tendências entre os dois grupos sugerem que não resultam exclusivamente de intervenções institucionais. As condições de vida e de trabalho podem ajudar a explicar essas diferenças.

Diabetes Mellitus; Mortalidade; Estudos de Séries Temporais

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