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Convergence in mortality from ischemic diseases and diabetes mellitus at the regional level in Mexico (1998 – 2023)

Carmen Zúñiga-Trejo [1], Jesús Díaz-Pedroza [1], Raúl Enrique Molina-Salazar [1], Moisés Salvador Castañeda-Ramírez [2] and José Federico Rivas-Vilchis [2,*]

[1] *Department of Economics, Metropolitan Autonomous University, Campus Iztapalapa, Mexico.*
[2] *Department of Health Sciences, Metropolitan Autonomous University, Campus Iztapalapa, Mexico.*

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Abstract

Objective: To determine whether health convergence exists across the Mexican states.

Design and setting: The two leading causes of death in Mexico were used as indicators of health. From data for the 32 Mexican states (1998 to 2023), a panel dataset was constructed using the concept of economic convergence, and three panel-data regression models were estimated. A standard deviation analysis determined the type of convergence.

Results: The estimates indicate conditional beta convergence for both causes of mortality and sigma convergence only for mortality from ischemic heart disease.

Conclusion: Mortality from ischemic heart disease would take approximately 26 years to reach half its steady state, while mortality from diabetes mellitus would do so in 10 years. Gross domestic product and public health expenditure are key determinants in explaining these trends. Sigma convergence in mortality from ischemic diseases indicates a trend towards homogenization, suggesting a reduction in regional disparities, which requires specific attention in public health policies.

Keywords: Convergence; Convergence Speed; Ischemic Diseases; Diabetes Mellitus; Panel Data

1. Introduction

In Mexico, life expectancy at birth is 72.6 years for men and 79 years for women, for a total average of 75.7 years [1]. Furthermore, life expectancy at age 65 is 18.4 years for men and 19.4 years for women. Currently, Mexico has the highest percentage of obesity among the member countries of the Organisation for Economic Co-operation and Development (OECD), with 75.2% of the population aged 15 and over affected [2]. In 2025, heart disease and diabetes mellitus were the leading causes of death in Mexico for both men and women. There were 95,935 deaths attributed to heart disease, of which 46.5% were women and 53.5% were men. Diabetes mellitus, meanwhile, caused 56,541 deaths, with 50.14% being women and 49.85% men [3]. The objective of this study is to determine whether health convergence occurred among Mexican states from 1998 to 2023. To determine health convergence, economic convergence analysis is applied to health indicators. Instead of using per capita income, mortality from ischemic heart disease and mortality from diabetes mellitus are used, as these two causes represent the first and second leading causes of death in Mexico, respectively. In this sense, using health convergence analysis, the following question is posed: Is there health convergence among Mexican states for the period 1998 to 2023? This study hypothesizes that if absolute beta convergence in health exists in Mexico, the evaluation using the two leading causes of death between 1998 and 2023,

* Corresponding author: José Federico Rivas-Vilchis

will show that the 32 states with the lowest mortality rates will grow at a faster rate until they reach the states with the highest mortality rates as a steady state. If the conditional beta convergence is present, the mortality will be explained by other variables, and each Mexican state will have its own steady state. Finally, if sigma convergence occurs, mortality will become more homogeneous across Mexican states over time.

2. Methods

The data comes from the General Directorate of Health Information (DGIS) of the Ministry of Health. Vital statistics and mortality rates for ischemic heart disease and diabetes mellitus are used in the query dashboards [4]. The information is available in long format by the federal entity for the period 1998 to 2023. Data on public health expenditure and gross domestic product come from the System of Health Accounts [5].

This study uses the economic convergence model proposed by Barro and Sala-i-Martin [6]. Economic theory discusses three types of convergence: absolute beta convergence, conditional beta convergence, and sigma convergence [7]. Applying the concepts of convergence to health, the first type of convergence is a tendency toward equalization of mortality across countries or regions. Over time, mortality is expected to be the same across all regions and countries, thereby reducing initial differences in mortality levels.

To test the hypothesis of absolute convergence, the determinants of the steady state, or the variables considered to explain mortality, must be included in the model. If the variables are not significant, we would have absolute convergence. However, if they are significant, we would observe the second type of convergence. This conditional beta posits that different steady states exist and that the coefficient b lies between 0 and 1. In this sense, each country or region tends to converge to its own steady state, so significant differences between territories may persist, even in the long term [8].

The third type of convergence, sigma, exists when the dispersion of mortality, measured by the variance, decreases over time. In the long term, the mortality rate would be expected to remain the same across all entities, regardless of their initial values. Therefore, a decrease in mortality inequality from these causes would be expected. This study uses mortality rates for the two leading causes of death in Mexico—cardiovascular disease and type 2 diabetes mellitus—to determine whether, over 25 years, they tend to converge across the 32 Mexican states. To analyze these spatial changes in health, a panel dataset is constructed, combining temporal and cross-sectional analysis [9 and 10]. The analyzed period spans from 1998 to 2023.

The equation used for the estimations is that of Barro and Sala-i-Martín [6]:

$$\frac{1}{j}\left(log\ x_{it} - logx_{i,t-j}\right) = a - \left(\frac{1 - e^{-bj}}{j}\right) logx_{i,t-j} + \ \varepsilon_{it}$$

Where:

$\frac{1}{j}\left(log\ x_{it} - logx_{i,t-j}\right)$= the logarithm of the mortality growth rate.

The coefficient of $logx_{i,t-j}$ is $-\left(\frac{1-e^{-bj}}{j}\right)$, which is the logarithm of the lagged mortality by one period, decreasing in magnitude as the time interval, j, between the initial period, $x_{i,t-j}$, and the final period, x_{it}, for a given b > 0.

This specification has the advantage that the interpretation of the coefficient b is the convergence rate to the steady state, where j represents the number of annual periods and b is the convergence rate as a percentage [11]. For beta convergence to occur, the coefficient must be negative, which would confirm its existence.

2.1. Calculation of the convergence time to the steady state

To calculate the number of years it would take to close half the distance to the steady state, the following equation is used [6 and 12].

$$logx_{it} - logx^{*} = e^{-bj}(logx_{i,t-j} - logx^{*})$$

Where x* represents the mortality corresponding to the steady state, which is hidden in a.

To find the time it takes to travel halfway, the following is established:

$logx_{it} - logx^{*}$=$0.5_{x}(logx_{i,t-j} - logx^{*})$

Solving for j in the previous equation, we obtain the time it takes to travel halfway:

$$0.5_{x}\left(logx_{i,t-j} - logx^{*}\right) = e^{-\hat{b}j}\left(logx_{i,t-j} - logx^{*}\right) \Longrightarrow 0.5 = e^{-\hat{b}j} \Longrightarrow j = -\frac{log0.5}{\hat{b}}$$

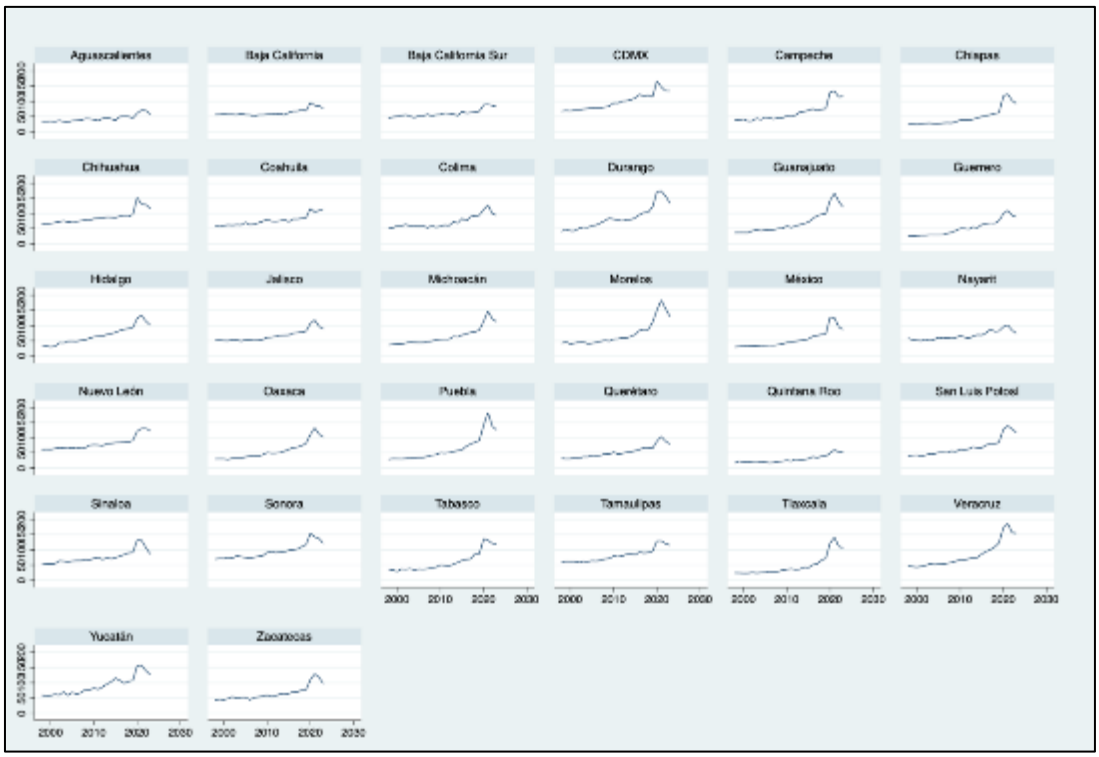
3. Results

Table 1 shows the percentage change in the two leading causes of death in Mexico from 1998 to 2023. Ischemic heart disease increased by 245.4% over 25 years. Furthermore, deaths from type 2 diabetes mellitus increased by 194.2%.

Table 1 Percentage change in the mortality rate in Mexico.

Cause of death	1998	2023	Change
Ischemic heart disease	43.96	107.9	245.4
Diabetes mellitus	43.12	83.74	194.2
Source: Own elaboration. Mortality rate per 1000 inhabitants.			

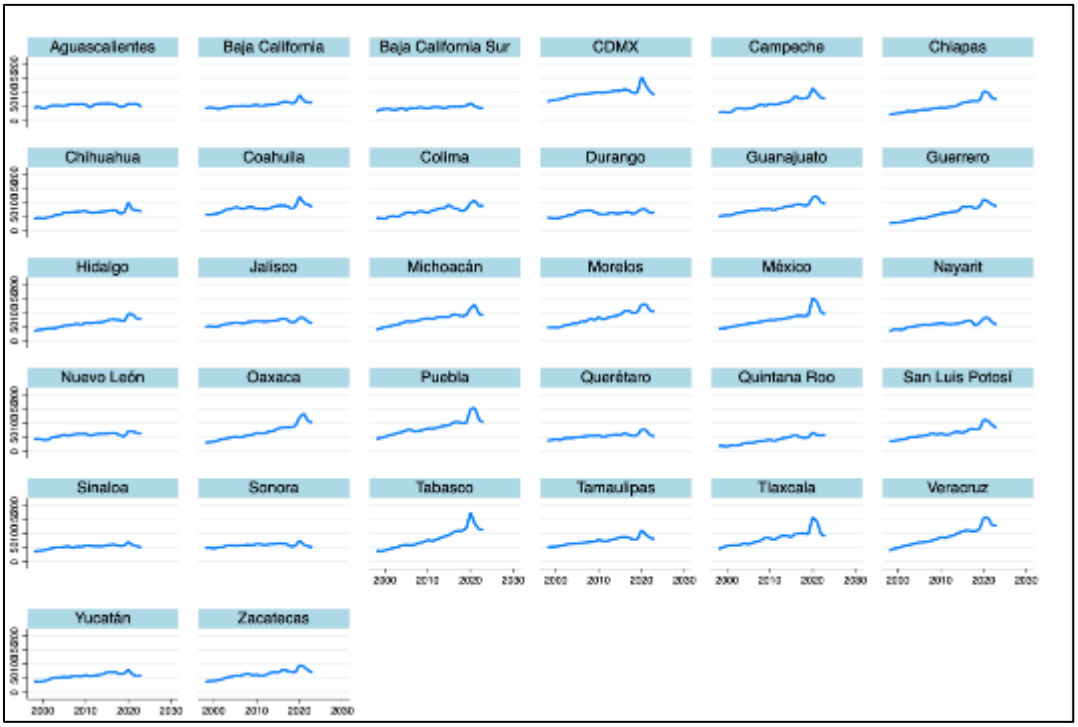
Figures 1 and 2 show the evolution of mortality from ischemic heart disease and diabetes mellitus, respectively, across the 32 Mexican states from 1998 to 2023. In several states, such as Veracruz, Tlaxcala, Morelos, Tabasco, Puebla, and Guanajuato, among others, the trend in deaths from ischemic heart disease showed exponential growth throughout the period see Figure 1.



Source: Own elaboration. Mortality rate per 1000 inhabitants.

Figure 1 Mortality rate from ischemic heart disease in Mexican federal entities, 1998 – 2023.

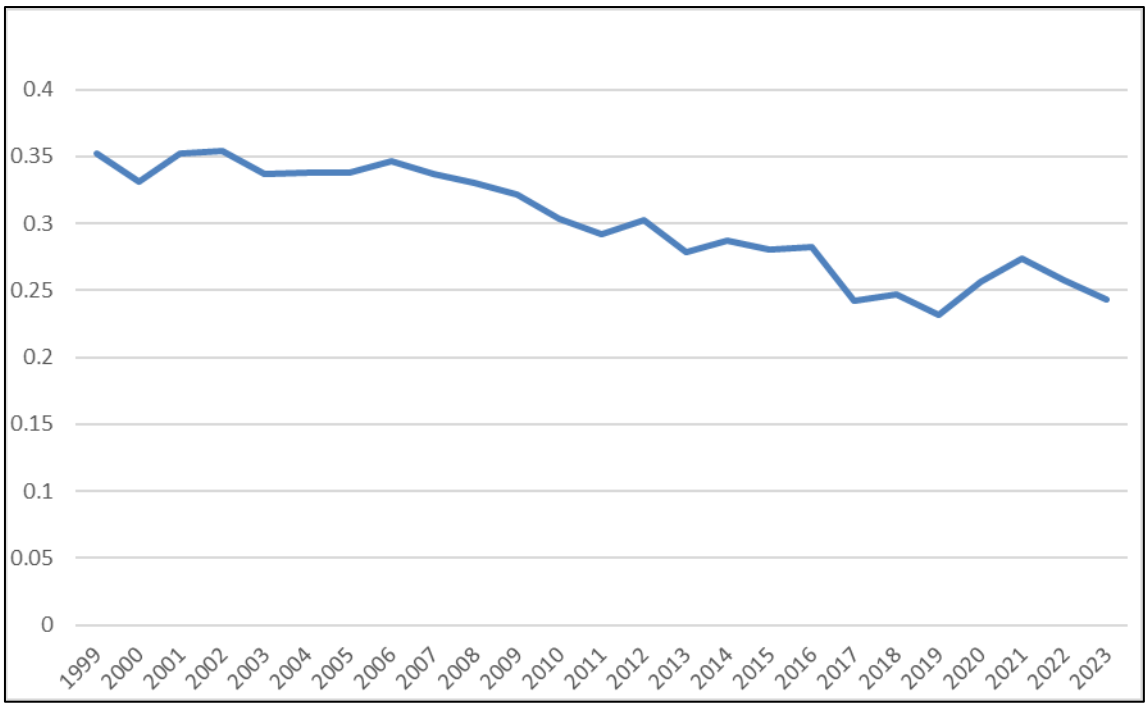
Figure 2 shows that the mortality rate from type 2 diabetes mellitus has remained almost constant in Aguascalientes, Baja California, Baja California Sur, Sinaloa, Sonora, Nuevo León, and Jalisco states, throughout the analyzed period. On the other hand, the other states show an increasing trend, most notably Tabasco, Tlaxcala, and Veracruz.



Source: Own elaboration. Mortality rate per 1000 inhabitants.

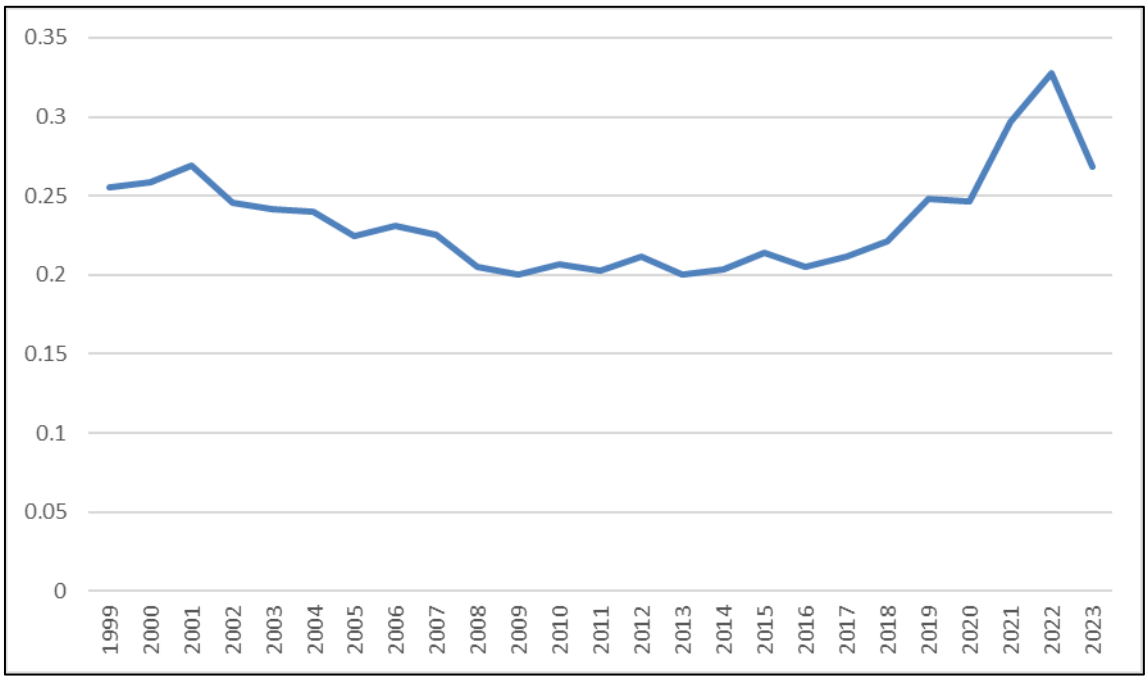
Figure 2 Mortality rate from type 2 diabetes mellitus in Mexican states, 1998–2023.

Figures 3 and 4 show the standard deviation of the logarithm of mortality from ischemic heart disease and type 2 diabetes mellitus, respectively. Considering the period as a whole, a clear reduction in the degree of dispersion in mortality from heart disease is observed. However, this trend was interrupted during the COVID-19 pandemic, but has since resumed. In the case of mortality from diabetes mellitus, it is not possible to conclude that the degree of dispersion has decreased.



Source: Own elaboration.

Figure 3 Standard deviation of the logarithm of mortality from ischemic heart disease, Mexico 1999–2023.



Source: Own elaboration.

Figure 4 Standard deviation of the logarithm of mortality due to diabetes mellitus, Mexico 1999 - 2023.

Table 2 Results of the absolute convergence β models for the Mexican federal entities (1998 – 2023).

	Model parameters			
Logarithm of the growth rate of mortality	**b (s.e.)**	**a**	**R^2**	**Time in years it takes to travel halfway (j)**
Ischemic heart disease	-.02501 (.0085)	0.313 (.0944)	within = 0.0096 between = 0.2546 overall = 0.0105	27.7
Type II diabetes mellitus	-.08366 (.0108)	1.0821 (.1694)	within = 0.1115 between = 0.0004 overall = 0.0696	8.25

Source: own elaboration.

Table 2 presents the results of the two estimations for determining absolute convergence, while Tables 3 and 4 present the results of the two estimations for determining conditional convergence. The interpretation of the results is one of the advantages of the model used, since the coefficient obtained provides the rate of convergence toward the steady state.

Table 3 Results of the conditional convergence model of the logarithm of death from ischemic heart disease.

	Model parameters			
	Logarithm of the growth rate of mortality from ischemic heart disease B (s.e.)	a	R^2	Time in years it takes to travel halfway (j)
Ischemic heart disease (lagged one period)	-.02639 (.0091)	0.3292 (.1321)	within = 0.0393 between = 0.2901 overall = 0.0432	26.3
Growth rate of public spending on health	.09850 (.0467)			
Growth rate of gross domestic product	-.1784 (.0374)			

Source: Own elaboration.

Table 2 shows that the b-value for death due to ischemic heart disease is -0.02501, indicating a convergence rate of 2.5% per year. This figure means that the gap between the growth rate of mortality from ischemic heart disease and the logarithm of the steady-state mortality rate for this cause decreases by 2.5% each year. In addition, the estimate for death due to type 2 diabetes mellitus is -0.08366, indicating a convergence rate of 8.4% per year. This figure suggests that the gap between the growth rate of mortality from type 2 diabetes mellitus and the logarithm of the steady-state rate decreases by 8.4% each year.

In Table 3, public health expenditure and gross domestic product were added as determinants of mortality to determine conditional convergence. Because they were statistically significant, conditional convergence is confirmed. The interpretation of the coefficients obtained is as follows: if public health spending increases by 1%, mortality from ischemic heart disease is predicted to increase by 0.1%; the sign of the public health spending coefficient is not as expected, since a negative effect is expected. On the other hand, if gross domestic product grows by 1%, mortality from ischemic heart disease is predicted to decrease by approximately 0.2%. The convergence rate is 2.6% per year, and it would take 26.3 years to reach the halfway point.

Similarly, for diabetes mellitus, if public health spending increases by 1%, mortality from the disease is predicted to increase by approximately 0.27%. If the gross domestic product grows by 1%, mortality from diabetes mellitus is predicted to decrease by approximately 0.18%. The convergence rate is 6.8% per year, and the time to reach the halfway point is approximately 10.2 years (see Table 4).

Table 4 Results of the conditional convergence β model, mortality due to type 2 diabetes mellitus.

	Model parameters			
Logarithm of the mortality growth rate	b (s.e.)	a	R^2	Time in years it takes to travel halfway (j)
Ischemic heart disease	-.02501 (.0085)	0.313 (.0944)	within = 0.0096 between = 0.2546 overall = 0.0105	27.7
Type 2 diabetes mellitus	-.08366 (.0108)	1.0821 (.1694)	within = 0.1115 between = 0.0004 overall = 0.0696	8.25

Source: own elaboration.

4. Discussion

In Mexico, the literature on economic convergence in health remains scarce, although it is a topic of interest in various international studies. Commonly used indicators include causes of mortality, life expectancy at birth, and public health expenditure. It is important to note that, in the context of economic convergence, reducing per capita income inequality between regions or countries is desirable. However, in the case of health indicators, the interpretation changes when it comes to causes of death, since convergence could indicate a trend toward poor health throughout the country if there is a high mortality rate from chronic degenerative diseases, for example.

Mortality convergence has become increasingly important in the European Union, especially after the accession of new members in 2004. Studies suggest that beta convergence reduces differences in mortality, while sigma convergence finds the opposite results [12]. For example, the beta convergence hypothesis has been verified for life expectancy in the European Union, with a convergence rate exceeding 1% per year [13]. However, another study found that European Union integration did not influence the convergence process in mortality, although sigma convergence was observed at the national level [14].

Specific studies have found beta convergence in cause-specific mortality in Poland, including the two leading causes of death in the country [15].

In this study, the negative coefficients associated with mortality from ischemic heart disease and diabetes mellitus confirm the existence of absolute beta convergence. The convergence rate is 2.5% per year for mortality from ischemic heart disease and 8.4% for mortality from diabetes mellitus. Furthermore, the estimated time to close half the distance to steady state is approximately 27.7 years for mortality from ischemic heart disease and 8.5 years for mortality from diabetes mellitus.

On the other hand, when the indicator is life expectancy at birth or public health expenditure, and regions or countries with lower life expectancy are growing faster than those with higher life expectancy, this would indicate a trend toward better health. Research in OECD countries has found that health expenditure per skilled worker converges in all countries, contributing to economic growth [16]. In G7 countries, no convergence was observed in under-five mortality rates, but convergence was observed in health expenditure [17]. In India, patterns of convergence and divergence were found in health, with sigma convergence in life expectancy at birth, but convergence and divergence in other indicators [18].

Unlike other studies, this analysis not only determined absolute beta convergence but also incorporated two important variables in explaining both causes of mortality: public health expenditure and gross domestic product, to test the hypothesis of conditional beta convergence. Since both variables were significant, conditional convergence is likely present.

Regarding sigma convergence, in the case of mortality from ischemic heart disease, Figure 3 shows a decrease in dispersion over the 25 years observed. For diabetes mellitus, Figure 4 shows that dispersion decreased until 2016, then increased to a peak in 2022, coinciding with the end of the COVID-19 pandemic, and subsequently decreased.

5. Conclusions

The detection of conditional convergence is crucial in regional policy, as it allows for an assessment of whether public health spending and gross domestic product are key factors in reducing existing disparities. In both estimates, the sign of the public health spending coefficient was positive, suggesting that, contrary to expectations, mortality increased rather than decreased. This could be due to a demand effect, in which public health spending responds to increased demand for health services driven by disease prevalence. Another possibility is inefficiency in resource allocation; that is, public health spending is not allocated efficiently across Mexican states. However, it would be advisable to conduct an efficiency analysis to determine the underlying cause.

The presence of conditional convergence indicates that Mexican states tend to converge to their own steady states, suggesting that differences between them may persist in the long term. The evolution of mortality from ischemic heart disease and diabetes mellitus can be observed in each state by analyzing the panel data charts. In the case of ischemic heart disease, the trend is increasing in most conditions, and some even show exponential growth. Sigma convergence suggests that the differences in mortality from this cause are decreasing over time. However, for diabetes mellitus, sigma convergence is not observed, indicating that the differences in this cause of death will not decrease in the long term.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] INEGI (National Institute of Statistics, Geography and Data Processing). Life expectancy at birth by federal entity according to sex, annual series from 2010 to 2026. 2026. Available from: https://www.inegi.org.mx/app/tabulados/interactivos/?pxq=Mortalidad_Mortalidad_9_06a0d2ff-b4c8-44af-9e6d-420f4a59fbc2

[2] OECD (Organisation for Economic Co-operation and Development). Life expectancy at 65. 2025]. Available from:https://www.oecd.org/en/data/indicators/life-expectancy-at-65.html

[3] INEGI (National Institute of Statistics, Geography and Data Processing). Registered deaths statistics (RDS). Available from:https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2026/edr/edr2025_RR in-jun.pdf

[4] DGIS. General Directorate of Health Information. Causes of death. 2025. Available from: https://sinaiscap.salud.gob.mx/DGIS/

[5] SICUENTAS. System of Health Accounts. Health Expenditure Classifiers. 2025. Available from: http://www.dgis.salud.gob.mx/contenidos/basesdedatos/da_sicuentas_gobmx.html

[6] Barro RJ, Sala-i-Martin X. Convergence. J Polit Econ. 1992;100(2):223-51.

[7] de la Fuente A, Caminal R, Esteban JM, Vives X. Growth and regional convergence in Spain and Europe. Vol. I. Barcelona: Institute for Economic Analysis; 1994.

[8] de la Fuente A, Caminal R, Esteban JM, Vives X. Growth and regional convergence in Spain and Europe. Vol. II. Barcelona: Institute for Economic Analysis; 1994.

[9] Arellano, M. (2003). Panel data econometrics. OUP Oxford.

[10] Baltagi, B. H. (2008). Econometric analysis of panel data (Vol. 4, pp. 135-145). Chichester: John Wiley & Sons.

[11] Goerlich F. Inequality, diversity, and convergence: (more) measurement tools. Regression models. Valencia: Valencian Institute of Economic Research, S.A.; 2001.

[12] Chiang AC. (1984). Fundamental Methods of Mathematical Economics. 3rd ed. London: McGraw-Hill Book Company;

[13] Stańczyk R. Convergence of Health Status in the European Union. Athens J Health. 2016;3(1):95-112.

[14] Hrzic, R., Vogt, T., Brand, H., & Janssen, F. (2021). The short-term effects of European integration on mortality convergence: a case study of European Union's 2004 enlargement. European Journal of Population, 37(4), 909-931.

[15] Kuropka, I., & Krupowicz, J. (2021). Spatial convergence of mortality in Poland. Bulletin of Geography. Socio-Economic Series, (54), 7-20.

[16] Celik, E. U., Omay, T., & Tengilimoglu, D. (2023). Convergence of economic growth and health expenditures in OECD countries: Evidence from non-linear unit root tests. Frontiers in Public Health, 11, 1125968.

[17] Mutlu, H., Bozkurt, G., & Türkoğlu, M. C. (2024). The Correlation between Economic Convergence and Health Indices in Developed Countries. Iranian Journal of Public Health, 53(1), 145 -56.

[18] Nag, A., Privara, A., Gavurova, B., & Pradhan, J. (2023). Does club convergence matter in health outcomes? Evidence from Indian states. BMC Public Health, 23(1), 2154.