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State and regional differences in the efficiency of public resources in the health sector in Mexico

Diferencias estatales y regionales en la eficiencia de los recursos públicos en el sector salud en México

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Abstract

The objective of this research is to determine the efficiency of public resources invested in health at the state level in Mexico during the period from 2001 to 2022; such an objective is justified because one of the purposes of the decentralization of public spending was to improve the quality and availability of services. Although regions and states have characteristics that make them heterogeneous, a large part of the literature indicates that the influence of public resources on the health of the population is usually positive; contrastingly, other studies emphasize that these effects are not significant, and even worsen the results of health indicators. For this reason, the Malmquist and Hicks-Moorsteen indices were used to analyze the productivity, technical efficiency, and technological change in the health sector, showing regional differences. Furthermore, our results suggest a pervasive loss of efficiency throughout the period studied.

JEL Code: C14, C43, D24, H51
Keywords: non-parametric; healthcare system efficiency; Hicks-Moorsteen index; Malmquist index

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Resumen

El objetivo de esta investigación es determinar la eficiencia de los recursos públicos invertidos en salud a nivel estatal en México durante el periodo de 2001 a 2022, justificado pues uno de los propósitos de la descentralización del gasto público fue mejorar la calidad y la disponibilidad de los servicios. Si bien las regiones y entidades federativas tienen características que las vuelven heterogéneas, una gran parte de la literatura señala que la influencia de los recursos públicos sobre la salud de la población suele ser positiva; en contraste, otros estudios enfatizan que dichos efectos no son significativos, e incluso empeoran los resultados de los indicadores en salud. Por esta razón, se analizan la productividad, la eficiencia técnica y el cambio tecnológico a través de los índices de Malmquist y de Hicks-Moorsteen, los cuales permiten observar diferencias regionales. Además, los resultados obtenidos sugieren una pérdida generalizada de eficiencia a lo largo del periodo de estudio.

Código JEL: C14, C43, D24, H51
Palabras clave: no paramétrico; eficiencia del sistema de salud; índice Hicks-Moorsteen; índice de Malmquist

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Introduction

This study aims to analyze the level of efficiency of public resources allocated to the health sector at the state level in Mexico from 2001 to 2022. This approach is justified because the proper use of such resources should improve quality of life, thereby increasing the productive capacities of the population. In this regard, Grossman (2017) points out that health constitutes a form of human capital. Indeed, a person's knowledge base increases their productivity, but their health stock determines the total time they can devote to production, and this can be increased through investment in improving health conditions. Thus, the efficiency of health systems should be a priority for governments (Gavurova et al., 2021) while ensuring continuous and equitable improvement in care (Asandului et al., 2014). It is also necessary to establish health programs focused on improving the quality of life of the lowest-income population (Laporte, 2002), as some empirical evidence suggests that health spending can reduce mortality, regardless of its source (Crémieux et al., 1999; Rahman et al., 2018).

Nevertheless, other research reveals that the effect on the quality of life of the population is greater if health care is financed with public resources (Rana et al., 2018; Novignon et al., 2012) or when the provision of public health services is more efficient than private services (Hollingsworth et al., 1999). In contrast to these results, Zakir and Wunnava (1999) found that government health care spending is ineffective at reducing infant mortality. Filmer and Pritchett (1999) observe that spending contributes little to improving child health, and that the level of female education and the degree of ethnic fragmentation have a greater impact on health indicators. Gravelle et al. (2003) document that health care can be inequitable with respect to ethnic origin, thereby reducing the efficiency of resource allocation, which should be based on need measurement. In extreme cases, a higher ratio of government spending on health care has been associated with lower population quality of life (Berger & Messer, 2002).

Although most empirical evidence suggests a positive correlation between government spending on health and improved health conditions among the population, it is necessary to establish measures for comparing the efficiency of spending in the health sector, since greater resources do not necessarily imply improved quality, availability, and efficiency of services in this sector (Gavurova et al., 2021). Accordingly, the literature suggests that governments should be cautious about increasing health spending across the board and should prioritize spending on services for lower-income populations (Gupta & Verhoeven, 2001). Additionally, in low-income countries, policies should be established to increase per capita spending, since poorly designed policies in this sector can increase the financial burden on households and force low-income families to compromise on food and educational opportunities (Alexander et al., 2003). Furthermore, the socioeconomic characteristics of the population indirectly influence the efficiency of the health sector (Hadad et al., 2013). In this context, the loss of efficiency can be attributed to various causes: greater income inequality (Varabyova & Schreyögg, 2013); capital expenditures that are not carried out correctly (Lacko et al., 2022); reimbursements for healthcare expenses (Bhat, 2005); infrastructure; as well as the material and human resources available (Spinks & Hollingsworth, 2009; Mohanta et al., 2021; Farantos & Koutsoukis, 2022).

The above clearly demonstrates the need to analyze the level of efficiency of public resources allocated to the provision of health services at the state level in Mexico, given the heterogeneity of its federal states, which exhibit profound differences in infrastructure, human resources, and technical resources. This would provide a plausible explanation for differences in health-sector productivity across states. After this introduction, this paper is structured into three sections: the first analyzes the literature on efficiency and government spending in the health sector, as well as its impact on quality of life. The second section explains how the Malmquist and Hick-Moorsteen indices, used to characterize changes in productivity and technical efficiency, are calculated, and how hierarchical cluster analysis is performed to analyze the evidence provided by the indices. The third section presents the empirical evidence obtained for the states in the period 2001-2022. Finally, the conclusions drawn from the results are presented, along with the limitations of the analysis.

Review of the literature

According to Asandului et al. (2014), health systems must be capable of guaranteeing services equitably and efficiently to generate continuous improvement in the health of the population (life expectancy at birth, infant survival rate, among others); consequently, the efficiency of the health system is associated

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with government or private spending. According to Xu et al. (2010), these expenditure items reflect the government's or households' capacity and willingness to improve access to health services and protect themselves from potential financial risks. For their part, Payne et al. (2007) identified how morbidity affects health expenditures, with considerable variation across expenditure categories and age groups, trends that are not stable over time, and implications for health systems and their management in the context of population aging in developed countries.

Filmer and Pritchett (1999) show that government spending on health accounts for less than 0.143% of the observed differences in infant mortality across 100 countries in 1990. Nonetheless, per capita income, income inequality, female education levels, ethnic fragmentation, and religion are more effective in reducing mortality. Gravelle et al. (2003) estimated improved needs-based resource allocation models for small geographic areas in England, using data on health resources and needs for the years 1991 and 1994-2000. Using methodological innovations such as calculating additional measures for specific morbidities, they found evidence of inequality regarding ethnic origin and suggested a way to reduce it.

In the United States, Laporte (2002) states that improving the health status of the lowest-income population requires focusing on raising their quality of life. This requires establishing government programs specifically focused on this goal, given that there is evidence that income transfer programs were ineffective at reducing mortality at the lower end of the income distribution. Crémieux et al. (1999) reviewed the association between health care spending and health outcomes for fifteen Canadian provinces over the period 1978–1992, observing that lower health care spending is associated with significantly lower life expectancy and higher infant mortality rates, even when differences in per capita health spending between provinces are small.

Zakir and Wunnava (1999) found that public health spending was not significantly associated with reduced infant mortality rates in 117 countries in 1993. Nonetheless, other variables also contributed significantly to their reduction, namely: female labor force participation, female literacy rates, and GDP per capita. In contrast, Hollingsworth et al. (1999) found that, in the case of the United States, public provision of health services is more efficient than private provision; however, since efficiency levels depend on market structure, concentration, and scope of services, attention must be paid to the products and inputs that determine productivity.

Berger and Messer (2002) observed, for 20 OECD countries between 1960 and 1992, that increases in healthcare spending are associated with lower mortality rates in developed countries, as well as with higher levels of education, lower income inequality, and higher levels of health insurance coverage. Nevertheless, when health spending is financed with public resources, mortality rates increase.

Dieleman et al. (2016) found, across a panel of 184 countries, that some spend more than 5% of their GDP on health but still fail to provide a basic package of services to their populations. Other countries spend proportionally less, but have achieved levels close to universal coverage. While there are financing gaps in the health sector worldwide, low-income country governments can increase their health budgets by improving tax collection and prioritizing health spending.

Rana et al. (2018), using data from 30 OECD countries for the period 2004 to 2015 and a panel model with corrected standard errors (PCSE), constructed an index of general health status that allowed them to determine that greater use of information technologies and a higher proportion of health spending financed with public resources improve health outcomes. They also found evidence of a negative influence of income inequality and ethnic diversity. For their part, Novignon et al. (2012) concluded, based on a fixed- and random-effects panel of 44 sub-Saharan African countries for 1995-2010, that government spending had a greater influence than private spending on life expectancy at birth, the crude mortality rate, and the infant mortality rate.

Rahman et al. (2018) used a generalized moments model to examine whether government and private health spending influence life expectancy at birth, the crude mortality rate, and the infant mortality rate across 15 Asian countries from 1995 to 2014. Their results reveal that both areas of health spending are relevant for reducing infant mortality rates. They also found that per capita income growth and sector infrastructure have positive effects on increasing life expectancy and reducing mortality rates.

For Gavurova et al. (2021), the quality and availability of health services are among the areas of the public sector where greater funding does not always lead to better results; therefore, it is necessary to establish criteria for comparison. In this regard, Gupta and Verhoeven (2001) used a free disposal hull (FDH) model to measure the efficiency of government health spending in 37 African countries for 1984-1995, and compared it with that of some Asian countries. On average, African countries were less efficient than Asian countries. The authors also point out that governments should carefully consider expanding health spending when initial levels are high, prioritizing increases in spending on services for low-income populations to ensure that spending does not become inefficient as quality of health care improves for the population.

Using data envelopment analysis (DEA), Alexander et al. (2003) evaluated the efficiency of public health systems in 51 developing countries, finding that policies need to be established to increase per capita spending in lower-income countries, particularly in sub-Saharan Africa, where spending is so low that health systems cannot function effectively. In a similar analysis, based on DEA and FDH models, Afonso and St. Aubyn (2005) compared the efficiency of the healthcare systems of 24 OECD countries, noting that three countries (Korea, Japan, and Sweden) are efficient regardless of the model used. The evidence also suggests that, to capture the effects of changes in efficiency, it is necessary to consider both the government spending allocated to the sector and the resources (physicians, nurses, hospital beds) available to it.

Bhat (2005) used DEA to assess the efficiency of healthcare delivery systems across 24 OECD countries, noting that countries with public contracts (subrogation) or public institutions dedicated to

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healthcare delivery are more efficient than those that reimburse healthcare expenses. In turn, countries that pay physicians a salary are more efficient than those that pay for every service individually. Seeking to assess whether the source of health expenditure financing affects the sector's productivity, Grosskopf et al. (2006) used DEA for 143 countries for the period 1977-1990, also constructing an index with efficiency estimates from a stochastic frontier model, and found that only middle-income countries show a positive correlation between public financing and improvements in quality of life.

Spinks and Hollingsworth (2009) employed the Malmsquist index to assess OECD countries over the period 1995-2000. They found a decline in average technical efficiency, as countries generally moved slightly away from the efficient frontier. Concerning technological change, they observed that it remained stable during the period, with an average close to unity, although countries such as Denmark and France did experience technological change. Varabyova and Schreyögg (2013) found that, in some OECD countries, there is no correlation between healthcare resource efficiency and good outcomes, as countries with technically more efficient hospital sectors have higher per capita healthcare spending, regardless of funding source (public or private). In addition, countries with greater income inequality are less technically efficient, resulting in longer patient stays in the medical unit.

Hadad et al. (2013) estimated the efficiency of the health systems of 31 OECD countries in 2007 using a DEA model. They determined that nine developed economies are the most efficient when only resources and their healthcare systems are included; however, when socioeconomic characteristics beyond the healthcare system are included, only two countries are found to be efficient. Lacko et al. (2022) evaluated the convergence objectives of the European Union (EU) cohesion policy in the area of health services. Their results for the Malmquist index show that, in most EU countries, technical efficiency values are high. Nevertheless, in Central and Eastern European countries, efficiency has declined, which can be explained by inefficient capital expenditures.

Kathuria and Sankar (2005) studied the performance of health systems in India's 16 major states for the period 1986-1997 using a stochastic production frontier model, finding that the states with the highest health indicators are not necessarily the most efficient. In this scenario, the government should focus on improving performance to provide more efficient care, rather than simply increasing investment in the health sector. Mohanta et al. (2021) evaluated the performance of 32 states in India during the COVID-19 pandemic using a DEA model, with inputs including public health expenditure, the number of hospitals, the number of hospital beds, the percentage of healthcare workers, population density, and the number of infected individuals. Recovered patients and fatalities were considered as outputs, with only 50% of states being efficient in healthcare.

Farantos and Koutsoukis (2022) calculated variations in productivity and technical efficiency in public hospitals in Greece for the period 2015 to 2019 using the Malmquist index. They observed that hospitals' technical efficiency follows an upward trend with some ups and downs. Nonetheless, inputs show a sustained increase in value, which does not translate into productivity gains. Consequently, inefficient resource use can be discerned.

Given the above, there is a clear need to analyze the efficiency of public healthcare services across Mexico's states. To do so, aspects such as allocated government spending, human resources, technical resources, and infrastructure (Gavurova et al., 2021) must be considered to provide more efficient care. This point of view is justified because, according to Grossman (2017), a greater stock of health will increase the overall productivity of the population.

Methodology

Based on an analysis of the specialized literature, it was decided to capture the dynamics of efficiency and technological change in the health sector using the Malmquist and Hicks-Moorsteen indices. In this regard, to calculate the change in productivity, Färe *et al.* (1994) propose using the geometric mean between two Malmquist indices, assuming that, for each period $t = 1, \dots, j$, technology S^t transforms inputs $x^t \in \mathbb{R}_+^N$ into outputs $y^t \in \mathbb{R}_+^M$, such that $S^t = \{(x^t, y^t): x^t \longrightarrow y^t\}$. The correspondence $L^t(y^t) = \{x^t: (x^t, y^t) \in S^t\}$ is then considered, which assigns to each product vector y^t the closed and convex set $L^t(y^t)$ containing the input vectors x^t with which it is possible to produce y^t; verifying also that $0 \notin L^t(y^t)$ when $y^t \geq 0$, $y^t \neq 0$, that $\hat{x}^t \geq x^t \in L^t(y^t) \Rightarrow \hat{x}^t \in L^t(y^t)$, and that $\hat{y}^t \geq y^t \Rightarrow L^t(\hat{y}^t) \subset L^t(y^t)$ (Färe *et al.*, 1992). It is then possible to define distance functions between inputs for different points in time using expressions of the type

$$\mathrm{D_i^t(y^t, x^t)} = \sup\left\{\lambda > 0 : \left(\mathrm{x^t}/_{\lambda}\right) \in \mathrm{L^t(y^t)}\right\} \tag{1}$$

According to Färe *et al.* (1994), based on these distance functions, the Malmquist input-based productivity index can be defined using the formula

$$\mathrm{M_i(x^{t+1}, y^{t+1}, x^t, y^t)} = \left[\frac{\mathrm{D_i^t(x^{t+1}, y^{t+1})}}{\mathrm{D_i^t(x^t, y^t)}} \frac{\mathrm{D_i^{t+1}(x^{t+1}, y^{t+1})}}{\mathrm{D_i^{t+1}(x^t, y^t)}}\right]^{1/2} \tag{2}$$

This index shows changes in productivity from time t to $t + 1$, such that: if $M_i(\cdot) > 1$, there is an increase in productivity; while $M_i(\cdot) < 1$ implies a decrease in productivity, and $M_i(\cdot) = 1$ means that there are no changes in productivity during the period.

In accordance with Färe *et al.* (1992), to explicitly separate technological change and efficiency, the Malmquist index can be re-expressed as follows:

$$\mathrm{M_i}(\mathrm{x}^{t+1},\mathrm{y}^{t+1},\mathrm{x}^{t},\mathrm{y}^{t}) = \frac{\mathrm{D}_i^{t+1}(\mathrm{x}^{t+1},\mathrm{y}^{t+1})}{\mathrm{D}_i^{t}(\mathrm{x}^{t},\mathrm{y}^{t})}\left[\frac{\mathrm{D}_i^{t}(\mathrm{x}^{t+1},\mathrm{y}^{t+1})}{\mathrm{D}_i^{t+1}(\mathrm{x}^{t+1},\mathrm{y}^{t+1})}\frac{\mathrm{D}_i^{t}(\mathrm{x}^{t},\mathrm{y}^{t})}{\mathrm{D}_i^{t+1}(\mathrm{x}^{t},\mathrm{y}^{t})}\right]^{1/2} \tag{3}$$

where the first factor on the right-hand side of equation (3) measures the change in efficiency, while the second factor captures the change in technology between the two periods evaluated.

For O'Donnell (2010), the Malmquist index, because of its relatively simple decomposition, is among the most widely used indices for measuring productivity. However, this index has the complication that it cannot be expressed as a ratio between production and input indices. In contrast, the Hicks-Moorsteen index, by construction, is multiplicatively complete; therefore, it is consistent with the correlation among quantities (outputs and inputs). To decompose this index, it is necessary to take as a starting point the distance functions of outputs and inputs, respectively, in equations (4) and (5):

$$D_O^t(x,q) = \min_{\delta}\left\{\delta > 0 : \left(x, {}^{q}/_{\delta}\right) \in T^t\right\} \tag{4}$$

$$D_I^t(x,q) = \max_{\rho}\left\{\rho > 0 : \left({}^{x}/_{\rho}, q\right) \in T^t\right\} \tag{5}$$

where Tt denotes the production possibilities (technology) established in period t. Product distance measures the inverse of the maximum homothetic expansion of the product vector that is feasible while keeping the input vector fixed; thus, it is a measure of technical efficiency. Input distance, on the other hand, measures the maximum contraction of the input vector that makes a fixed product vector feasible. Both are linearly homogeneous and non-decreasing (O'Donnell, 2010). Based on the properties of homogeneity and monotonicity of the distance functions, the relation between the amount of production and inputs used can be implicitly defined, which can be expressed as:

$$Q_{ms,nt} = \frac{Q(q_{nt})}{Q(q_{ms})} = \frac{D_O^t(x_{nt}, q_{nt})}{D_O^t(x_{nt}, q_{ms})} \tag{6}$$

where producer n in period t is compared to producer m in period s, under conditions of equal inputs.

Implicitly aggregating distance function quantities enables consistent evaluation of variations in production over time. This will allow changes in productivity and efficiency to be obtained by aggregating

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distance functions using the geometric mean, which, according to O'Donnell (2010), ensures that the axioms of monotonicity, homogeneity, identity, and proportionality, which are fundamental to index number theory, are satisfied. In this regard, Hicks (1961) emphasizes that the correlation between the measure of production and inputs quantifies the efficiency with which resources are combined; for this reason, this research follows Diewert's (1992) proposal to represent this correlation using the Hicks-Moorsteen index as follows:

$$\mathrm{TFP}_{\mathrm{ms,ns}}^{\mathrm{HM}} = \left[\frac{D_O^t(x_{nt}, q_{nt}) D_O^S(x_{ms}, q_{nt})}{D_O^t(x_{nt}, q_{ms})\ D_O^S(x_{ms}, q_{ms})} \frac{D_I^t(x_{ms}, q_{nt}) D_I^S(x_{ms}, q_{ms})}{D_I^t(x_{nt}, q_{nt}) D_I^S(x_{nt}, q_{ms})}\right]^{1/2} \tag{7}$$

By construction, index (7) is consistent with the core definition of total factor productivity (TFP), and being multiplicatively complete, it allows for the identification of variations in technical progress and efficiency improvements, which are considered the main drivers of productivity growth (O'Donnell, 2010).

To identify similarities among states in specific years, based on the research's variables of interest, hierarchical cluster analysis was performed. Using an unsupervised learning algorithm based on the notion of proximity provided by a weighted Euclidean metric $d_{ij} = \sqrt{\sum_{k=1}^{p} w_k^2 \cdot \left(x_{ik} - x_{jk}\right)^2}$ on $\mathbb{R}^p$, clusters are formed in which: each point is considered a group, points that are within a minimum range of proximity are considered a group, and for the formation of other clusters, the distance between them is maximized (Everitt *et al.*, 2011:p.77-80). Cluster analysis allows dendrograms to be drawn (see Figures 2 and 3) that represent the similarities between elements of a set based on the clusters shown in a branching diagram. A dendrogram starts with a root, branching out to connect with nodes. Each node represents a group or cluster, and each of these can be connected to secondary nodes. The branches are represented by lines that end in leaves at the bottom of the dendrogram, which represent individual points or elements in the analyzed set. The length of each branch provides information about the proximity of the elements, indicating their degree of similarity. The elements in the center of the dendrogram usually represent the least dissimilar elements, those closest to a centroid from which distances to the other elements are measured (Everitt *et al.*, 2011).

Some stylized facts

At the end of the 1980s, Mexico began decentralizing health services at the subnational level through agreements transferring resources, responsibilities, and powers to the states. Although this process took

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place gradually (López, 2012), starting in the 1990s, allocations to the states were clearly established due to the addition of Chapter V to the Fiscal Coordination Law.

Figure 1 shows the evolution of federalized health spending as a percentage of GDP, which reflects a change in the dynamics of resource decentralization during the period analyzed, since in 2012 the resources allocated to the states doubled due to the incorporation of the Resources for Social Protection in Health (RPSS; Spanish: Recursos para Protección Social en Salud), which were intended to provide health services to people without access to social security schemes. From 2012 onwards, spending remained relatively constant, averaging 0.8% of GDP until the end of the period. It peaked in 2020, at 0.9% of GDP, coinciding with the onset of the COVID-19 pandemic.

Such stability suggests limited variation in resource allocation to this sector after the initial increase. Furthermore, Sovilla and Díaz (2022) note that the decentralization process granted states greater autonomy in managing resources; however, differences in socioeconomic needs and inequalities, as well as mismanagement of allocated funds, limited the impact of decentralization on the health sector. Additionally, with the disappearance of Seguro Popular (Popular Insurance) and the creation of Insabi (Spanish: Instituto de Salud para el Bienestar) in 2020, a reversal of the centralization of health services began, as seen in the downward trend on the far right of Figure 1.

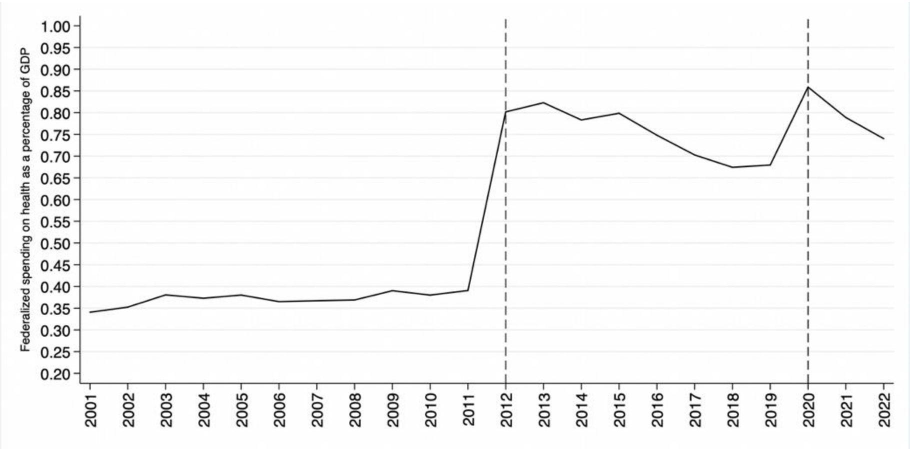

Figure 1. Federalized spending on health as a percentage of GDP, 2001–2022
Source: created by the authors

Aiming to analyze the efficiency of resource use in the health sector, this study used data published in the State and Municipal Public Finance Statistics, compiled by the National Institute of Statistics and Geography (INEGI; Spanish: Instituto Nacional de Estadística y Geografía), for the period 2001-2022; as well as state expenditure budgets (PEE; Spanish: Presupuestos de Egresos Estatales) for

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several fiscal years to determine the amount of state funding allocated to health. Expenditure data were adjusted to constant 2013 prices annually. For the health sector, state-level resources (available beds, physicians, and nurses per thousand inhabitants) were sourced from information published by the General Directorate of Health Information of the Ministry of Health (SSA; Spanish: Secretaría de Salud). Data on infant survival rates[1] and life expectancy at birth, taken from INEGI, were considered outputs derived from health services.

Thus, due to the availability of information, seven variables were used. Five of them represent inputs: number of physicians per thousand inhabitants ($\mathrm{M_{it}}$), number of nurses per thousand inhabitants ($\mathrm{N_{it}}$), number of beds per thousand inhabitants ($\mathrm{B_{it}}$), health expenditure[2] as a proportion of state GDP (sGDP) ($\mathrm{GS_{it}}$), and per capita health expenditure ($\mathrm{gs_{it}}$). The remaining two variables are considered outputs: infant survival rate ($\mathrm{SI_{it}}$) and life expectancy at birth ($\mathrm{EN_{it}}$).

A hierarchical cluster analysis was performed for the states of Mexico using 2002 data, seeking similarities across all input variables and using life expectancy at birth as the output. This analysis generated the dendrogram shown in Figure 2, which distinguishes five groups of states. Observation of these clusters reveals that the only state that did not show similarities with others in relation to the variables analyzed was Mexico City (CDMX), which had the highest life expectancy at birth (76.98 years), the highest number of physicians (9.71), nurses (13.53), and beds (8.02) per thousand inhabitants, but whose health expenditure as a proportion of sGDP was the lowest. In contrast, the group comprising Chiapas (CHIPS), Hidalgo (HGO), Guanajuato (GTO), Guerrero (GRO), Michoacán (MICH), Oaxaca (OAX), Puebla (PUE), Tabasco (TAB), and Veracruz (VER) had the highest average health expenditure as a proportion of sGDP (0.98 percentage points) along with the lowest average life expectancy at birth, 4.4 years lower than the corresponding figure for Mexico City. The complete results for all groups are presented in Table 1.

[1]Which is calculated, following the approach of Afonso and St. Aubyn (2005), as:

$$\mathrm{TS} = \frac{1000 - \text{Infant mortality rate}}{\text{Infant mortality rate}}$$

where Infant mortality rate $= \ 100 \cdot (\text{Children who died before 12 months of age})/\text{Births}$

[2]Health expenditure is considered to be the amount received by the states through the Health Services Contribution Fund (FASSA) under Branch 33, plus the amounts allocated by the states to health in their expenditure budgets for the corresponding fiscal year.

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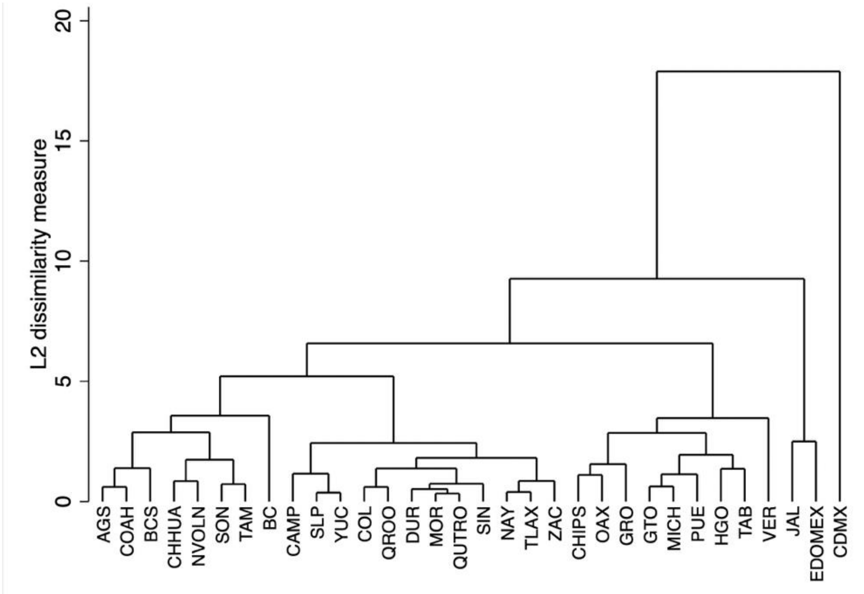

Figure 2. Dendrogram of cluster analysis for states, 2002
Source: created by the authors

Table 1
Hierarchical cluster analysis for states, mean values per group for the year 2002

Group	States	Life Expect. at Birth	Health expenditure (% sGDP)	Health expenditure (per capita)	Physicians	Nurses	Beds
1	AGS, BC, BCS, COAH, CHHUA, NVOLN, SON, TAM	76.26	0.78	547.52	0.98	1.44	0.976
2	CAMP, COL, DUR, MOR, NAY, QUTRO QROO, SLP, SIN TLAX, YUC, ZAC	74.075	0.81	464.23	0.75	1.02	0.73
3	CHIPS, GTO, GRO, MICH, OAX, PUE, TAB, VER	72.58	0.98	1 415.97	1.87	2.31	2.04
4	JAL, EDOMEX	75.15	0.67	5 162.78	4.02	5.46	5.08
5	CDMX	76.98	0.18	2 977.46	9.71	13.53	8.02

Source: created by the authors
Note: Health expenditure (% of GDP) is reported in percentage points; health expenditure in per capita terms at constant 2013 prices; variables for physicians, nurses, and beds are expressed per thousand inhabitants.

To get a first look at how health performance has changed over time across the states, the cluster analysis was repeated for the final year of the sample (2022) using the same six variables, yielding the

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dendrogram shown in Figure 3. Four groups can be observed that capture similarities in states' life expectancy, health sector resources (beds, physicians, nurses), and health expenditure (as a proportion of sGDP and per capita). The third group, comprising Guanajuato, Guerrero, Jalisco (JAL), Oaxaca, Puebla, Veracruz, and Chiapas, includes the states with the lowest average life expectancy at birth (73.59 years), but at the same time the highest average health expenditure as a proportion of sGDP (2.13%), and the highest average expenditure in per capita terms ($6 268.93 at 2013 prices). In contrast, the second group, comprising Hidalgo, Michoacán, Tabasco, Tamaulipas (TAM), and Chihuahua (CHHUA), has the lowest average health expenditure as a proportion of sGDP (1.14%), but a slightly higher average life expectancy at birth (74.48 years).

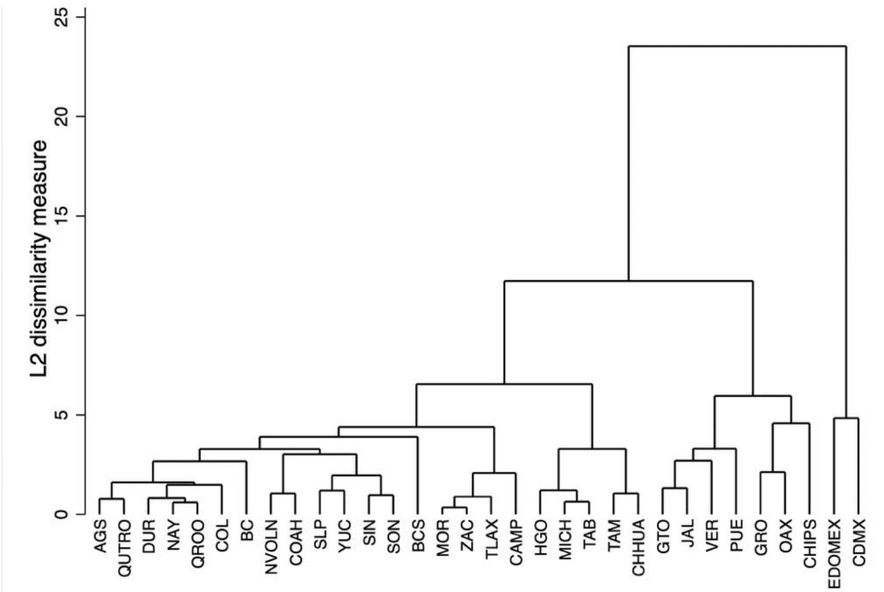

Figure 3. Dendrogram of cluster analysis for states, 2022
Source: created by the authors

The complete results for the average values of the variables in all groups are presented in Table 2. It can be noted that the states of Guanajuato, Guerrero, Oaxaca, Chiapas, Puebla, Veracruz, Michoacán, and Tabasco were among the two worst-performing groups in 2002 and remained so in 2022. Furthermore, life expectancy at birth did not show notable progress in any group over the 20-year period. Nonetheless, the most important observation is that in 2002, the states associated with the highest health expenditure as a proportion of sGDP had the lowest life expectancy at birth, a situation that did not reverse by 2022.

Table 2
Hierarchical cluster analysis for states, mean values per group for the year 2022

Group	States	Life Expect. at Birth	Health expenditure (% sGDP)	Health expenditure (per capita)	Physicians	Nurses	Beds
1	AGS, DUR, MOR, NAY, NVOLN, BC, QUTRO, QROO, SLP, SIN, SON TLAX, BCS, YUC, ZAC, CAMP, COAH, COL	75.50	1.25	1 097.01	1.27	2.73	1.02
2	HGO, MICH, TAB, TAM, CHHUA	74.48	1.14	1 478.76	2.66	5.35	1.95
3	GTO, GRO, JAL, OAX, PUE, VER, CHIPS	73.59	2.13	6 268.93	4.34	8.77	3.16
4	EDOMEX, CDMX	75.61	0.84	4 591.29	9.4	19.45	7.58

Source: created by the authors
Note: Health expenditure (% of GDP) is reported in percentage points; health expenditure in per capita terms at constant 2013 prices; variables for physicians, nurses, and beds are expressed per thousand inhabitants.

Cluster analysis suggests systematic differences among states in the efficiency with which they use health sector resources. For this reason, following the approach of Färe *et al.* (1994), the analysis will be enriched by calculating the Malmquist index with variable returns to scale and input orientation. According to equation (3), it is possible to disaggregate productivity (efficiency) variations and technological change in the sector. Following the approach of Afonso and St. Aubyn (2005), which states that to capture the effects of changes in efficiency, it is necessary to consider both government spending and available resources, the index is constructed using as inputs the number of physicians, nurses, and beds per thousand inhabitants, together with health spending as a proportion of state GDP, while the two outputs (life expectancy at birth and infant survival rate) are used.

Based on estimates of the Malmquist index (MI) and technological change (TC), it was found that in 2002, all states in the northern region showed a decline in efficiency, with Tamaulipas (9.2%) and Nuevo León (NVOLN) (6.6%) exhibiting the most dramatic decreases. Nevertheless, in terms of technological change, Baja California (BC) and Nuevo León had increases of 1.1% and 8.2%, respectively. That same year, four states in the north-central region saw productivity increases: Baja California Sur (BCS) with 3.1%, Jalisco with 0.5%, Nayarit (NAY) with 0.8%, and San Luis Potosí (SLP) with 1.8%. The state with the greatest loss of productivity in the region was Aguascalientes (AGS) with 12.2%, although it had a positive technological change of 1.1%, as did Baja California Sur with 3.1% and Jalisco with 1.11%.

In the central region, efficiency increases were observed in Mexico City (4.0%), the State of Mexico (EDOMEX) (1.3%), Morelos (MOR) (5.1%), and Tlaxcala (TLAX) (0.1%). Nevertheless, productivity declined in the other states, with Puebla experiencing the largest drop, equivalent to 14.6%. Likewise, the states that experienced positive technological change were Mexico City (0.8%), the State of Mexico (2.4%), and Morelos (1.0%). In the south, Chiapas (5.0%), Yucatán (YUC) (0.2%), and Oaxaca (0.1%) saw productivity increases; Chiapas (1.1%) and Quintana Roo (QROO) (2.1%) were the only states with positive technological change.

In 2012, only 43.75% of the states registered an increase in productivity: in the northern region, Sonora (SON) with 0.5%; in the north-central region, Durango (DUR) 0.5%, Michoacán 0.9%, Nayarit 8.4%, Sinaloa (SIN) 2.1%, and Zacatecas (ZAC) 18.7%; in the center, Guanajuato 2.4%, Hidalgo 6.3%, Morelos 3.3%, Puebla 3.8%, and Tlaxcala 33.5%—which was the state with the highest productivity growth that year—; and in the south, Chiapas 13.8%, Yucatán 1.3%, and Quintana Roo 9.0%. In terms of technological change, 14 states showed increases: in the north, Baja California (BC) 5.0%, Chihuahua 1.0%, and Tamaulipas 3.1%; in the north-central region, Aguascalientes 1.2%, Nayarit 5.0%, and Sinaloa 3.0%; in the center of the country, Guanajuato 1.6%, Hidalgo 5.0%, Morelos 5.5%, Querétaro (QUTRO) 2.3%, and Tlaxcala 4%; and in the south, Chiapas 5.0%, Tabasco 1.8%, and Quintana Roo 2.9%.

In 2022, 78.13% of the states exhibited an increase in efficiency, with the only states showing decreases being: Nuevo León (0.5%), Jalisco (8.5%), Mexico City (16.3%), State of Mexico (28.1%), Morelos (11.8%), Tlaxcala (33.7%), and Yucatán (25.3%). In terms of technological change, 96.88% of states showed increases; the only federal entity to experience a decline was Mexico City, which fell 16.3%. Finally, when the Malmquist index is calculated for the entire period 2002-2022, two states show an increase in efficiency: Sonora with 1.1% and San Luis Potosí with 1.5%. Moreover, the only state that maintained its productivity throughout the entire period was the State of Mexico, presenting a unit value. All other states showed net decreases in efficiency, with similar figures for technological change. Table 3 contains all the results obtained.

Table 3
Malmquist Index and technological change in the healthcare sector at the state level, 2002-2022

Northern Region												
State	2002		2007		2012		2017		2022		2002-2022	
	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC
BC	0.998	1.011	0.921	1.111	0.875	1.050	1.024	0.858	1.103	1.120	0.965	0.972
COAH	0.984	0.987	0.997	0.850	0.983	0.963	1.063	1.065	1.151	1.105	0.989	0.955
CHHUA	0.983	0.969	1.019	0.839	0.960	1.010	1.134	1.073	1.008	1.136	0.979	0.953
NVOLN	0.934	1.082	0.958	0.832	0.835	0.955	0.974	0.855	0.995	1.097	0.994	0.962
SON	0.983	0.969	0.958	1.023	1.005	0.950	1.052	0.920	1.483	1.085	1.011	0.967
TAM	0.908	0.969	1.007	0.832	0.932	1.031	1.006	0.940	1.057	1.156	0.984	0.967
North-Central Region												
State	2002		2007		2012		2017		2022		2002-2022	
	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC
AGS	0.878	1.011	0.963	1.402	0.994	1.012	0.972	0.774	1.100	1.070	0.994	0.975
BCS	1.031	1.031	1.090	1.090	0.958	0.958	0.899	0.899	1.127	1.127	0.979	0.979

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COL	0.865	0.982	1.124	1.155	0.982	0.978	1.008	0.915	1.048	1.111	0.975	0.978
DUR	0.885	0.989	0.844	0.951	1.005	0.941	0.965	1.031	1.020	1.082	0.977	0.966
JAL	1.005	1.011	1.027	0.832	0.998	0.976	0.854	0.966	0.915	1.081	0.972	0.946
MICH	0.910	0.980	0.901	0.832	1.009	0.930	0.834	1.059	1.380	1.046	0.936	0.936
NAY	1.008	0.989	1.161	1.402	1.084	1.050	0.970	1.058	1.106	1.083	0.977	0.956
SLP	1.018	0.989	1.048	1.086	0.797	0.941	0.999	1.033	1.232	1.171	1.015	0.975
SIN	0.932	0.979	0.919	1.351	1.021	1.030	0.877	0.999	1.445	1.024	0.979	0.968
ZAC	0.926	0.989	0.846	1.076	1.187	0.994	1.022	0.999	1.515	1.086	0.965	0.964

Central Region

State	2002		2007		2012		2017		2022		2002-2022	
	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC
CDMX	1.040	1.008	0.994	0.832	0.943	0.942	0.973	1.034	0.837	0.859	0.962	0.966
EDOMEX	1.013	1.024	0.947	0.832	0.960	0.937	1.090	1.075	0.719	1.069	1.000	0.948
GTO	0.926	0.989	0.956	0.832	1.024	1.016	1.093	0.926	1.055	1.099	0.973	0.955
HGO	0.977	0.986	0.242	0.899	1.063	1.050	0.985	1.036	1.416	1.023	0.949	0.957
MOR	1.051	1.010	0.980	1.294	1.033	1.055	1.236	0.877	0.882	1.076	0.995	0.975
PUE	0.854	0.992	0.964	1.045	1.038	0.994	0.964	1.058	1.082	1.104	0.972	0.973
QUTRO	0.966	1.000	0.916	1.398	0.813	1.023	0.876	0.974	1.615	1.068	0.985	0.970
TLAX	1.001	0.989	0.916	0.951	1.335	1.040	1.018	1.039	0.663	1.083	0.949	0.960

Southern Region

State	2002		2007		2012		2017		2022		2002-2022	
	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC	MI	TC
CAMP	0.975	0.975	0.898	0.832	0.944	0.944	1.043	1.049	1.081	1.081	0.947	0.947
CHIPS	1.050	1.011	0.945	1.086	1.138	1.050	0.991	0.999	1.191	1.010	0.980	0.975
GRO	0.998	0.989	1.076	1.057	0.988	0.966	0.954	1.010	1.586	1.048	0.985	0.959
OAX	1.001	0.989	0.955	1.130	0.934	0.941	0.986	1.058	1.256	1.063	0.985	0.957
QROO	0.977	1.021	1.177	1.195	1.090	1.029	0.837	0.879	1.075	1.075	0.998	0.980
TAB	0.982	0.989	1.041	1.155	0.833	1.018	0.985	1.058	1.101	1.028	0.995	0.965
VER	0.922	0.989	1.013	0.832	0.975	0.992	0.919	1.046	1.102	1.064	0.966	0.949
YUC	1.002	0.969	0.968	1.023	1.013	0.950	1.007	0.972	0.747	1.097	0.975	0.973

Source: created by the authors based on estimates
Note: If the value of MI or TC >1, there is an increase (productivity or technological change) in the period; when MI or TC < 1, there is a decrease; finally, MI or TC = 1 indicates that efficiency remains unchanged.

Figure 4 compares states based on their efficiency and technological change results derived from the Malmquist index for the years 2002 (panel a) and 2022 (panel b). To group states by performance, two reference lines are established that indicate the unit value on each axis. These allow the states to be separated into four quadrants: the first quadrant contains states that showed an increase in both productivity (efficiency) and technology; the second quadrant contains states that showed productivity improvements but a decline in technology; the third quadrant contains states that showed declines in both productivity and technology; and the fourth quadrant contains states with improvements in technology but declines in productivity. It turns out that, for 2002, Durango, Colima (COL), Puebla, Tamaulipas, Michoacán, Veracruz, Zacatecas, Guanajuato, Sinaloa, Campeche (CAMP), Hidalgo, Chihuahua, Guerrero, Tabasco, Sonora, and Coahuila (COAH) are in the third quadrant; while six states are in the first quadrant: Mexico City, the State of Mexico, Chiapas, Morelos, Baja California Sur, and Jalisco. In contrast, by 2022, most states were in the first quadrant, with only Mexico City in the third quadrant. This

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outlines the dynamics of the health sector in the states, using evidence obtained from the Malmquist index and its components as criteria.

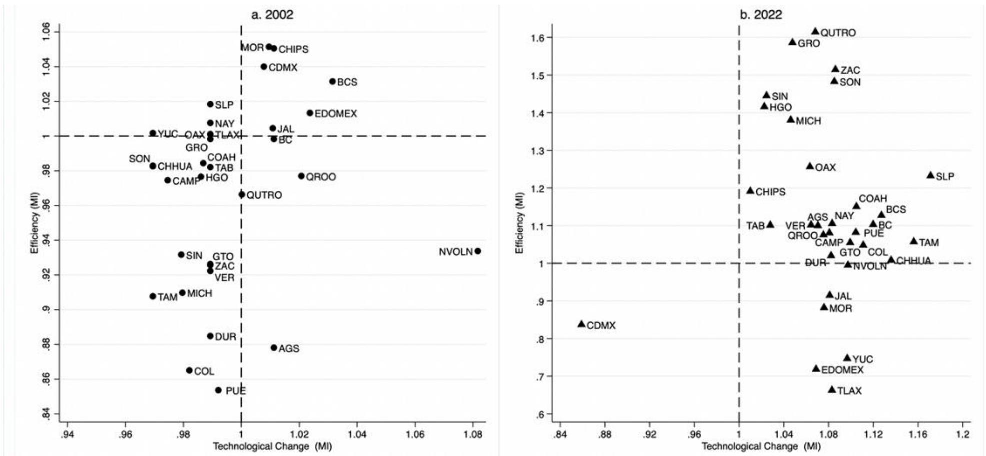

Figure 4. Scatter plot of Malmquist index components (efficiency versus technological change) for the state health sector, 2002 and 2022
Source: created by the authors

Additionally, for comparison with previous results, the Hick-Moorsteen index was calculated using the same input and output specifications. According to O'Donnell (2010), this is a complete multiplicative index that supports a breakdown of changes in total factor productivity (TFP) into an efficiency component and a technology component; in addition, the reference DEA model can be estimated without prior knowledge of input prices. The results for the northern region show that all states experienced a loss of efficiency over time; only Chihuahua achieved a year without a loss of efficiency, being the state with the lowest average loss of efficiency. In the north-central region, there was also a loss of efficiency in all states, with Baja California Sur having the smallest average decrease (2.92%). In the center of the country, all states experienced a decline in efficiency, with Mexico City and Querétaro showing the slightest drastic decreases, while Guanajuato was the least efficient state. In the southern region, overall efficiency decreased. These results are similar to those from the Malmquist index, showing a general decline in efficiency between 2002 and 2022. Nonetheless, the Hicks-Moorsten decomposition does not provide empirical evidence of any increase in efficiency during the period analyzed. Table 4 shows the mean, maximum, and minimum values of the Hicks-Moorsten estimates over the period.

Table 4
Levels of efficiency (sTFP) in the health sector in the states, 2001-2022

State	Mean	Max	Min	State	Mean	Max	Min
Northern Region							
BC	0.5213	0.6795	0.4152	NVOLN	0.6350	0.9956	0.2507
COAH	0.6382	0.8631	0.0762	SON	0.3707	0.7395	0.2866
CHHUA	0.6491	1.0000	0.2354	TAM	0.2415	0.4443	0.1385
North-Central Region							
State	Mean	Max	Min	State	Mean	Max	Min
AGS	0.6136	0.8195	0.3770	MICH	0.4374	1.0000	0.1717
BCS	0.9708	1.0000	0.8012	NAY	0.6808	0.9511	0.2958
COL	0.3117	0.6545	0.2018	SLP	0.3721	0.7729	0.2337
DUR	0.4596	0.6070	0.3680	SIN	0.3580	0.4386	0.2805
JAL	0.2714	0.4652	0.1719	ZAC	0.5330	0.9397	0.3725
Central Region							
State	Mean	Max	Min	State	Mean	Max	Min
CDMX	0.7967	0.9336	0.6251	MOR	0.4563	0.6542	0.3251
EDOMEX	0.2273	0.3718	0.0919	PUE	0.1975	0.8449	0.1339
GTO	0.1306	0.2779	0.0626	QUTRO	0.7423	1.0000	0.5059
HGO	0.1762	0.2791	0.0630	TLAX	0.5159	0.8279	0.4334
Southern Region							
State	Mean	Max	Min	State	Mean	Max	Min
CAMP	0.773	1.000	0.334	QROO	0.4643	0.6303	0.3383
CHIPS	0.2128	0.2661	0.1425	TAB	0.2279	0.3598	0.1533
GRO	0.1737	0.2451	0.1379	VER	0.1497	0.2396	0.0769
OAX	0.2209	0.4419	0.1334	YUC	0.4235	0.6555	0.2870

Source: created by the authors based on the breakdown of the Hicks-Moorsteen index
Note: If the mean of sTFP > 1, there is an increase in efficiency; if sTFP < 1, there is a decrease; when sTFP = 1, efficiency remains unchanged.

Regarding technological change, Table 5 presents empirical evidence from the decomposition of the Hicks-Moorsteen index. It can be seen that, for the northern part of the country, although some states had considerable increases in technology, such as Chihuahua with 76.64% in 2004, Nuevo León with 45.49% in 2008, and Coahuila with 22.83% in 2022, on average between 2001 and 2022, the entire northern region experienced declines in technology. In the north-central region, Baja California Sur recorded a 9.89% increase in technology during the period, making it the only state in the country with an average above 1. The other states in this region experienced losses in technology; in fact, Jalisco, San Luis Potosí, and Sinaloa are below the national average (43.60%). In the center, the State of Mexico, Guanajuato, Hidalgo, and Puebla were the states that failed to exceed the national average. In the south, Chiapas, Guerrero, Oaxaca, Tabasco, Yucatán, and Veracruz did not reach the national average; however, this region includes the state with the highest increase in technology in 2008, Campeche, at 126.2%.

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Table 5
Technology levels (MP) in the health sector in the states, 2001-2022

Northern Region							
State	Mean	Max	Min	State	Mean	Max	Min
BC	0.5593	0.7397	0.4384	NVOLN	0.7347	1.4549 (2008)	0.4087
COAH	0.7425	1.2283 (2022)	0.1276	SON	0.3898	0.6601	0.2881
CHHUA	0.8132	1.7664 (2004)	0.4689	TAM	0.2910	0.7265	0.2156
North-Central Region							
State	Mean	Max	Min	State	Mean	Max	Min
AGS	0.6430	0.8799	0.3528	MICH	0.5320	1.1957 (2008)	0.2007
BCS	1.0986	1.3763 (2022)	0.9505	NAY	0.7292	1.2678 (2022)	0.5158
COL	0.3784	0.9873	0.2495	SLP	0.3793	0.6751	0.2671
DUR	0.4608	0.6244	0.3591	SIN	0.3701	0.4676	0.3040
JAL	0.2974	0.4286	0.1969	ZAC	0.5445	0.8371	0.4324
Central Region							
State	Mean	Max	Min	State	Mean	Max	Min
CDMX	0.8543	(1.0191)	0.6352	MOR	0.4823	0.8648	0.3237
EDOMEX	0.2701	0.6089	0.1187	PUE	0.2323	0.8864	0.1456
GTO	0.1568	0.3464	0.0958	QUTRO	0.8074	1.3092 (2022)	0.6293
HGO	0.2181	0.4612	0.1390	TLAX	0.5315	0.7522	0.4336
Southern Region							
State	Mean	Max	Min	State	Mean	Max	Min
CAMP	0.948	2.262 (2008)	0.609	QROO	0.5017	0.7264	0.4032
CHIPS	0.2230	0.2916	0.1718	TAB	0.2485	0.3587	0.1648
GRO	0.1851	0.3341	0.1378	VER	0.1773	0.4477	0.1319
OAX	0.2254	0.4510	0.1741	YUC	0.4312	0.5925	0.2959

Source: created by the authors based on the breakdown of the Hicks-Moorsteen index
Note: If the mean of MP > 1, there is an increase in technology; if MP < 1, there is a decrease; if MP = 1, technology remains unchanged.

Figure 5 presents scatter plots of health expenditure as a proportion of sGDP against efficiency measured using the Hicks-Moorsteen decomposition for 2002 (panel c) and 2022 (panel d). To group states according to their performance, reference lines are drawn at the national average for each axis and each panel, generating four quadrants: the first quadrant contains states with above-average health expenditure and efficiency; the second quadrant contains those with health expenditure above the national average but below-average efficiency; the third quadrant comprises states that are below average on both variables; and the fourth quadrant groups states that are above average in efficiency but with expenditure below the national average. In 2002, Hidalgo, Jalisco, the State of Mexico, Nuevo León, and Michoacán were located in the third quadrant; while Coahuila and Chihuahua (northern region), Aguascalientes and Zacatecas (north-central), Querétaro, Mexico City, and Tlaxcala (central), and Campeche and Yucatán (southern region) were in the first quadrant. By 2022, the national average for efficiency had increased, but the national average for health spending had decreased; however, Coahuila and Chihuahua (northern region) remained in the first quadrant, as did Mexico City (center), Aguascalientes (north-central), and Campeche (south). The most notable change in 2022 is seen in the composition of the third quadrant, which increased to 14 states, most of them in the southern (Veracruz, Yucatán, Tabasco, Guerrero, and Oaxaca) and central (Guanajuato, Hidalgo, Tlaxcala, and State of Mexico) regions.

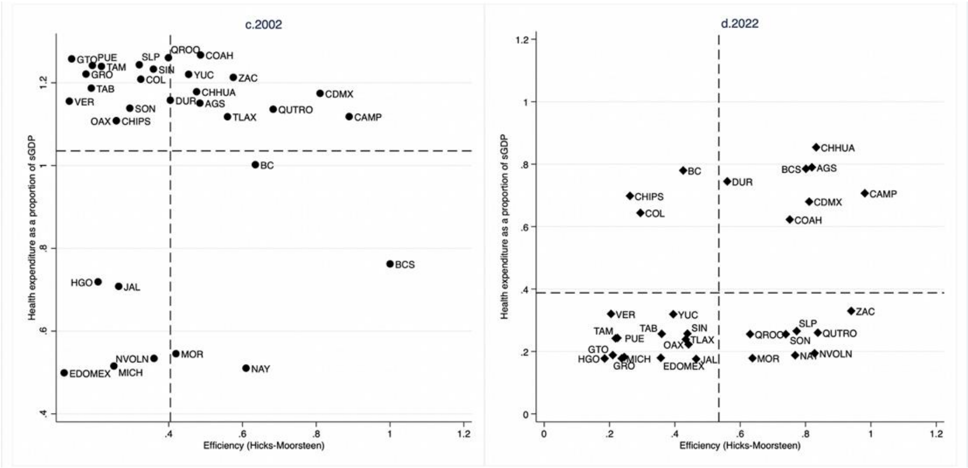

Figure 5. Scatter plot of health expenditure as a proportion of sGDP versus efficiency (Hicks-Moorsteen), 2002 and 2022
Source: created by the authors

Estimates of the Malmquist and Hicks-Moorsteen indices provide insights into efficiency and technological change in the health sector that are consistent in some respects but inconsistent in others across the country's states and regions.

In terms of efficiency, calculated based on the decomposition of the Malmquist index, while it is true that the aggregate calculation for the period 2002-2022 indicates that only two states saw increases in efficiency while one maintained its level, it can also be observed that the calculations for specific years

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reveal that 11 states improved their performance in 2002, 11 improved in 2007, 16 increased their efficiency in 2012, 13 in 2017, and 25 states increased their efficiency in 2022. According to the Hicks-Moorsteen index breakdown, no state experienced average efficiency gains during the analyzed time interval. Only four states maintained constant efficiency in specific years, while most experienced widespread efficiency losses between 2002 and 2022. In fact, except for the overall improvement in efficiency in 2022, as measured by the Malmquist index, both indices show widespread efficiency losses over the period, though the picture is more dramatic when viewed through the Hicks-Moorsteen decomposition.

The technological change component of the Hicks-Moorsteen index shows its best positive results in the first third of the period (2008) and at the end (2022), but overall presents a picture of technological loss. According to Malmquist's decomposition, the years with the best results in technological change were 2007 (when 18 states showed increases) and 2022 (when only Mexico City showed a decrease in technology). In the remaining years analyzed, most states showed a decline in technology. In summary, both indices paint a picture of negative technological change throughout the period, with a slight upturn in the first third and a substantial improvement toward the end. The case of Mexico City is striking: in 2002, it was one of the most efficient states with the highest technological levels, only to exhibit one of the worst performances in 2022.

The widespread improvement in efficiency and technological change observed in 2022 could partly be explained by the general decline in health expenditure as a percentage of sGDP toward the end of the analysis period. Indeed, using Figure 4 as an analytical tool, the states that can be classified as the most inefficient are those in the second quadrant, as they have higher health spending than the national average but below-average efficiency. Of the 13 states that were in the second quadrant in 2022, two remained in the same quadrant in 2022. Among the 11 that changed quadrants, nine moved to the third quadrant, indicating that the change was driven by a substantial decrease in health spending rather than a substantive improvement in efficiency. Colima and Sonora, which were in the third quadrant in 2002, moved to the fourth quadrant, indicating that, in addition to a decrease in health spending, they experienced a substantial increase in efficiency. Conversely, only Baja California moved from the fourth quadrant in 2002 to the second in 2022, showing a substantial decrease in efficiency despite a smaller decline in health spending as a proportion of sGDP than in the other states.

Empirical evidence suggests differences in technical efficiency across Mexican states. As an example, in 2022 Mexico City and the State of Mexico were among the states with the highest per capita health expenditure of $4 591.29, on average and at 2013 prices, but with a loss of efficiency according to the Malmquist index (with figures of 0.837 and 0.719, respectively) and with technological decline according to the Hicks-Moorsteen decomposition (figures of 0.811 and 0.357, respectively). Similarly, Jalisco had the highest per capita health expenditure ($15 650.67 at 2013 prices), but showed technical inefficiency according to the Hicks-Moorsten index and low productivity according to both indices. In contrast, states such as Zacatecas, which spent the least on health ($964.53 per capita at 2013 prices) and had fewer physicians, nurses, and beds per thousand inhabitants, showed a higher level of technical efficiency (0.937, Hicks-Moorsteen estimate) in 2022.

Conclusions

Productivity, technical efficiency, and technological change in the health sector were estimated using Malmquist and Hicks-Moorsteen indices, with product-oriented data envelopment analysis and variable returns to scale, to characterize the efficiency of public resources allocated to the health sector at the state level in Mexico for the period 2001-2022. The inputs used were the expenditure allocated to the health sector at the state level that the states received through the Health Services Contribution Fund (FASSA; Spanish: Fondo de Aportaciones para Servicios de Salud) and the resources in their respective state expenditure budgets, together with the number of doctors, nurses, and beds per thousand inhabitants. The objectives defined as desirable products were life expectancy at birth and infant survival rate.

Although the results of the indices differ from one another, they generally offer empirical evidence of widespread loss of productivity and technical efficiency, and of the absence of technological progress in the sector throughout the study period, coinciding with the conclusions of research carried out for other geographical settings, such as that of Spinks and Hollingsworth (2009), Lacko et al. (2022) and Mohanta et al. (2021). These results call into question the decentralization of health services in Mexico. In this regard, Sovilla and Díaz (2022) point out that, since resources from Branch 33 are allocated to the health sector based on the infrastructure available to the states, their needs and the inequalities between them are neglected. This is even more serious when considering the argument put forward by Gravelle et al. (2003) that the efficient allocation of health spending should be tailored to the specific needs of the sector.

Added to this is the fact that increased resource allocation to the health sector will not necessarily lead to better-quality or more available services (Gavurova et al., 2021). One aspect to consider in future research on Mexico concerns the overall level of income and its distribution, as documented by Grosskopf et al. (2006) and Varabyova and Schreyögg (2013), who found that these variables influence the efficiency of the health sector.

In summary, the stylized facts on the efficiency of the health sector at the state level suggest that regional differences in efficiency persist over time, even as per capita spending has increased. The general situation is that the sector’s material and human resources have expanded, but in this scenario, the states have generally shown a decline in efficiency.

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