



Efficiency analysis of the public health sector in Mexico using data envelopment analysis

Jesús Díaz-Pedroza¹, Carmen Zúñiga-Trejo¹, José F Rivas-Vilchis^{2*}, Raúl E Molina-Salazar¹, Moisés S Castañeda-Ramírez²

¹ Department of Economics, Metropolitan Autonomous University, Iztapalapa, México

² Department of Health Sciences, Metropolitan Autonomous University, Iztapalapa, México

Corresponding Author: José Federico Rivas-Vilchis

Abstract

To estimate the efficiency of spending on medicines and health supplies, and its effect on life expectancy at birth and other health outcomes in Mexico. Data from the Directorate of Health Information (2023) at the state level were used to analyze the hypotheses. Budgetary and human resource inputs and outputs, such as life expectancy, length of hospital stay, and hospital discharges, were considered. The efficiency of the public health sector was calculated using Data Envelopment Analysis (DEA). Models with constant and variable returns to scale were calculated. Under variable returns, the number of efficient states increased, and average efficiency improved from 56% to 78% with one input, and from 78% to 87% with multiple inputs. Our study demonstrates the importance of spending on medicines and healthcare personnel in increasing life expectancy, and that medical personnel are key to reducing hospitalizations, thus improving healthcare efficiency.

Keywords: Data envelopment analysis models, efficiency, drug expenditure, life expectancy, human resources in health

Introduction

The objective of this work is to evaluate the efficiency of spending on medicines and human resources as healthcare inputs, and their impact on health outcomes, including life expectancy at birth, length of hospital stay, and hospital discharges. To this end, Data Envelopment Analysis (DEA) will be used to analyze efficiency in the public health sector in Mexico. This method allows for establishing a functional relationship between the use of human and physical resources and health outcomes, even if this relationship is not explicitly defined.

One of the most relevant inputs for this study is expenditure on medications, as it is a key indicator of social investment in a region or country and represents a significant portion of public health spending in Mexico. Its effects are reflected in improvements in human health and quality of life, as well as in the sustainability of the health system. On the output side, life expectancy at birth is selected because it is one of the most widely used indicators of a population's health. The question this study poses is: What is the efficiency of expenditures on medications and human resources in improving life expectancy at birth, hospital discharges, and length of hospital stay at the state level in Mexico?

Literature Review

Several recent studies that used Data Envelopment Analysis (DEA) to evaluate healthcare efficiency were reviewed. This DEA technique has been applied in several countries to measure the efficiency of health systems. However, studies for the Mexican case are scarce. One of them evaluates the efficiency of 335 health centers in the state of Michoacán (2000-2017) and finds that the health centers with the largest resource allocations were not always the most efficient [1]. In the Mexican context, hospital strategic alliances are more efficient [2]. Internationally, studies have found that in Ecuador (2018), at the state level, Loja and Cotopaxi should reduce medical and administrative staff and

available beds by 15% and 6%, respectively [3]. In Egypt, only 4 out of 26 hospitals were efficient during the COVID-19 pandemic [4]. In Poland, measuring the efficiency of the healthcare sector between 2013 and 2018 revealed that accreditation certificates, waiting list length, and medical staff are factors that influence the efficiency of healthcare protection [5]. In Malaysia, the average efficiency level was found to be similar in pharmacy services in specialized and non-specialized public hospitals [6].

The DEA has also been used to measure efficiency in groups of countries. In 55 nations, including the 37 member countries of the Organization for Economic Co-operation and Development (OECD), during the COVID-19 pandemic, the countries with the highest average system efficiencies were Estonia, Iceland, Latvia, Luxembourg, the Netherlands, and New Zealand. From a financial perspective, the countries that used fewer resources to achieve the same level of recovery were Algeria, Estonia, Finland, Iceland, Ireland, Latvia, Luxembourg, Mexico, Morocco, the Netherlands, New Zealand, Romania, Slovenia, and Tunisia [7]. In 36 African countries, 58.33% were found to be efficient, and the number of nurses and the Gini coefficient significantly affected the inefficiency of health systems [8]. In emerging countries, factors influencing healthcare efficiency include research and development and improved physician training, which have contributed to healthcare efficiency in low-, middle-, and high-income countries [9].

Selection of inputs and outputs

Inputs. In Mexico, spending on drugs has accounted for approximately 11% of public health expenditure (PHE) over the last three decades, with a significant impact on the economy and society. In fact, statistically speaking, spending on drugs has more than tripled in constant pesos since 2006, rising from \$31,147.06 to \$111,026.16 (Mexican pesos) in 2022 (see Figure 1).

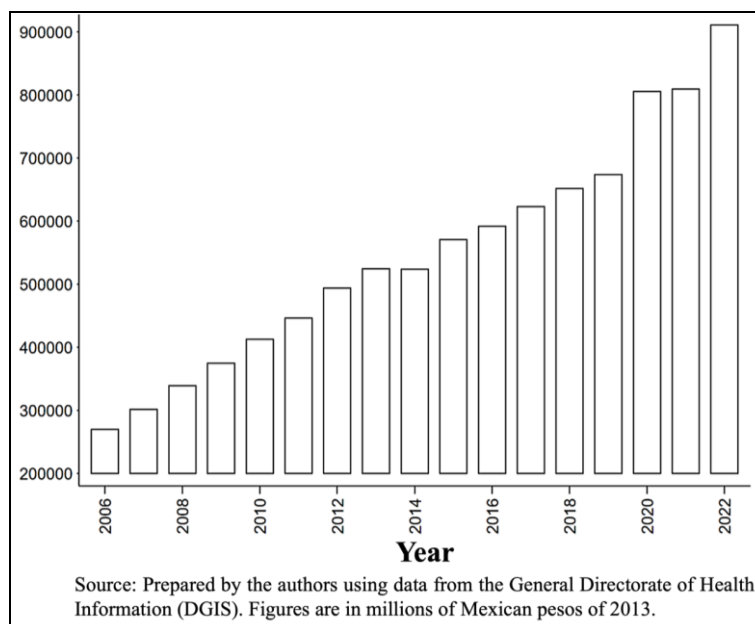


Fig 1: Public health expenditure in Mexico (2006-2022) in Mexican pesos of 2013

Health and pharmaceutical spending have increased in Mexico, see Figures 1 and 2 [10]. However, pharmaceutical spending remains low compared to that of OECD member countries [11], which range between 10% and 20% of total PHE. For example, Slovakia, Greece, and Hungary exceed 20%, while Spain reaches 15.7%; Denmark and Norway

remain around 10%. These figures reflect the diversity of priorities in pharmaceutical spending among countries. A notable case is the United States, where pharmaceutical spending accounts for 10% of PHE and is the highest worldwide. However, it has significant limitations in access to health services for vulnerable populations.

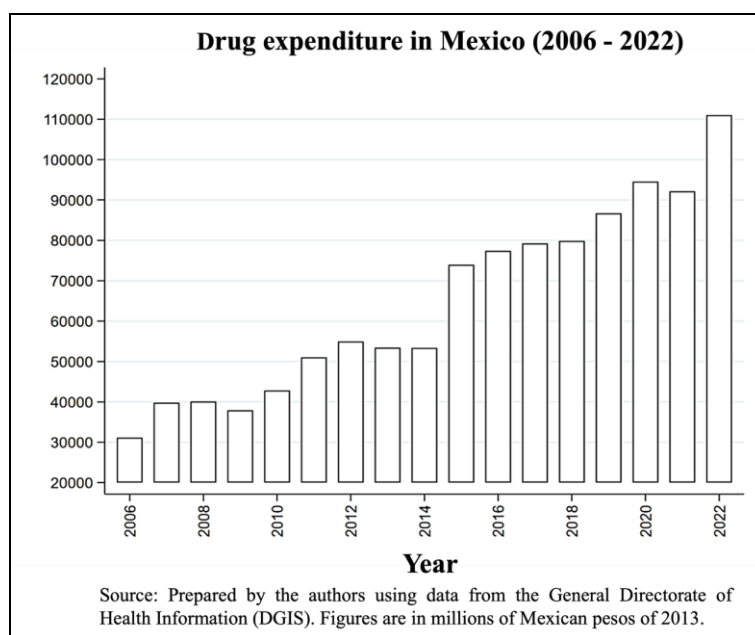


Fig 2: Drug expenditure in Mexico (2006-2022) in Mexican pesos of 2013

Drug spending varies significantly among high-income countries: the United States of America, with an unequal health system, spends more than 2.33% of its GDP on drugs,

while Denmark and Norway, with outstanding health systems, allocate around 1.1%, see Table 1.

Table 1: Comparison of spending on medicines in OECD member countries

Country		%		
		2022	2023	2024
Canada	GDP	1.914	1.971	1.965
Canada	HE	17.268	17.618	17.396
Denmark	GDP	0.968	1.1	1.057
Denmark	HE	10.213	11.56	11.257

France	GDP	2.248	2.191	--
France	HE	18.997	19.051	--
Germany	GDP	2.2	2.12	--
Germany	HE	17.674	18.053	--
Italy	GDP	1.786	1.712	1.719
Italy	HE	20.185	20.365	20.355
Japan	GDP	2.068	1.999	--
Japan	HE	16.784	18.613	--
Spain	GDP	2.032	1.924	--
Spain	HE	20.988	20.868	--
United States of America	GDP	2.26	2.333	--
United States of America	HE	13.673	13.973	--

Source: Prepared by the authors using data from the OECD.

OECD: Organization for Economic Co-operation and Development. GDP: Gross domestic product. HE: Health expenditure.

Regarding the number of hospital beds, during the press conference at the National Palace, Mexican President Claudia Sheinbaum Pardo highlighted the statements of the head of the Social Security Institute, who emphasized that 29,500 beds were added during the Institute's founding period (1943–1982), while only 4,300 were added between 1982 and 2018, despite the growth in the number of beneficiaries. "This lag explains the levels of saturation and prolonged waiting times at various times," he noted ^[12].

In Mexico, 2020 figures show a doctor density of 2.4 per thousand inhabitants and 2.1 consultations per capita, ranking it second among countries with the fewest consultations per capita. The OECD average is 3.7 doctors per thousand inhabitants. Likewise, the density of nurses per thousand inhabitants is 2.94, making it the sixth-lowest in the world. In terms of infrastructure, the number of hospital beds is 0.99 per 1,000 inhabitants, compared with the OECD average of 4.4.

Life expectancy at birth in Mexico is projected to be 75.7 years in 2025, with a notable gender gap: women live 79 years, while men reach 72.6 years, meaning women live approximately 6.4 years longer than men. It is noteworthy that in some states, women exceed 80 years of life expectancy, such as in Aguascalientes (80.3 years), Baja California (80 years), Baja California Sur (80.5 years), Coahuila (80.5 years), Mexico City (80.2 years), Chihuahua (80 years), Sonora (80.1 years), and Nuevo León (81.1 years). From 2010 to 2025, women gained approximately 2 years of life expectancy, while men gained 1.3 years ^[13]. Life expectancy in Mexico, compared to OECD member countries, remains among the lowest, even when broken down by gender.

In Mexico, the average length of hospital stay in 2025 was 3.8 days. This indicator is key to measuring hospital efficiency worldwide. A shorter length of stay is associated with greater efficiency, while a longer stay may indicate an inappropriate use of resources.

According to 2022 figures, hospital discharges in Mexico are 3,011 per 100,000 inhabitants, placing Mexico among the lowest hospital discharge rates among OECD member countries ^[14].

Data and Methods

Data from the Directorate of Health Information (DGIS) for the 32 Mexican states (2023) were used to process hypotheses. The nonparametric technique called Data Envelopment Analysis (DEA) was used to measure the joint efficiency of a set of resources, called inputs, relative to another set of variables or activities, commonly called

outputs. In other words, the aim is to analyze the relationship between inputs and outputs.

Charnes, Cooper, and Rhodes (1978) were pioneers in the application of the DEA methodology, which is based on linear programming and, specifically, on the ideas developed by Farrell (1957) ^[15, 16]. Farrell proposes a way to empirically measure efficiency, noting that economic theory shows efficient behavior in production, cost, and benefit functions. However, in practice, these functions are unknown ^[17]. The non average parametric DEA technique allows for estimating the relative efficiency of a production unit or firm compared to other units (DMUs) with which it is simultaneously being compared. The results obtained are measures of relative efficiency, not absolute efficiency, and indicate which DMUs use inputs most efficiently compared to other units, assuming an input-oriented model. Conversely, if a higher output is obtained with the same inputs, the unit operates under an output-oriented model ^[18]. Units located on the production frontier are classified as efficient. If working with an input-oriented model and a given output level, these units represent the ideal combination of inputs to obtain that output ^[19]. On the other hand, units located outside the frontier are considered inefficient. The level of efficiency is measured by the ratio between the distance from the origin to the projected point on the boundary and the distance from the origin to the point of the unit in question.

Charnes, Cooper, and Rhodes (1978) evaluate technical efficiency under the assumption of Constant Returns to Scale (CRS), and these types of models are known as CCR models, with two variants: input-oriented and output-oriented. Meanwhile, the BCC models (Banker, Charnes, and Cooper, 1984) allow for the evaluation of technical efficiency under the assumption of Variable Returns to Scale (VRS) ^[20].

Results and discussion

To identify the Decision-Making Units (DMUs) that optimally utilize available resources in the Mexican healthcare sector, four DEA models were developed [21, 22]. Models 1 and 2 consider one input and multiple outputs, while models 3 and 4 are multi-input and multi-output. Furthermore, all four models were calculated under CRS and VRS. Under CRS, the efficient frontier is steeper, resulting in fewer efficient DMUs. With VRS, the efficient frontier comprises more DMUs because the efficient frontier curve is convex and therefore more flexible. The models 1 and 2 treat medication expenditure as a single input and several outputs, including length of stay, life expectancy, and hospital discharges, see Figure 3 and Figure 4. The

models 3 and 4 incorporate the same outputs as models 1 and 2, but use multiple inputs.

To evaluate the efficiency of the inputs used for the 32 Mexican states or DMUs, the main statistics shown in Table 2 were calculated. Table 3 shows the results of the four calculated DEA models. Under the CRS model, only three DMUs reach a value of 1 (100% efficiency): Campeche, Tabasco, and Tlaxcala. They are followed by five DMUs that approach the efficiency frontier, with levels ranging from 71% to 80% (see Figure 3). Among them is Baja California Sur, which should decrease its input spending on medications by 27.93% to reach the frontier, or, maintaining

that same spending, increase outpatient visits by 67.14% and hospital stays by 59%, see Table 4.

Using the variable returns to scale (VRS) model, the number of entities comprising the efficient frontier increases to eleven DMUs: Baja California, Mexico City, Campeche, Chiapas, Colima, Guanajuato, Mexico State, Nuevo León, Sonora, Tabasco, and Tlaxcala. Furthermore, three entities are very close to the frontier: Jalisco, Chihuahua, and Aguascalientes (see Table 3 and Figure 3). According to Table 4, Jalisco could reach the efficient frontier if it reduces its spending on medications by 0.53% or, while maintaining that spending, increases the length of hospital stay by 6.6%.

Table 2: Statistical summary of the inputs and outputs used

Inputs	Average	Maximum	Minimum	Standard deviation
Total drug expenditure	2747857.8	13816913.0	472066.7	2697429.9
Drug expenditure (millions of Mexican pesos)	2.75	13.82	0.47	2.70
Total human resources	4.9	9.8	3.4	1.3
Outputs				
Hospital discharges	75125.5	228731.0	18672.0	54130.3
Days of hospital stay (year)	290448.4	1439565.0	61817.0	286299.2
Average length of stay (days)	3.7	6.3	2.02	1.01
Life expectancy at birth (years)	75.1	77.6	72.8	1.34

Source: Own estimate using DGIS data.

Table 3: Results of the DEA models

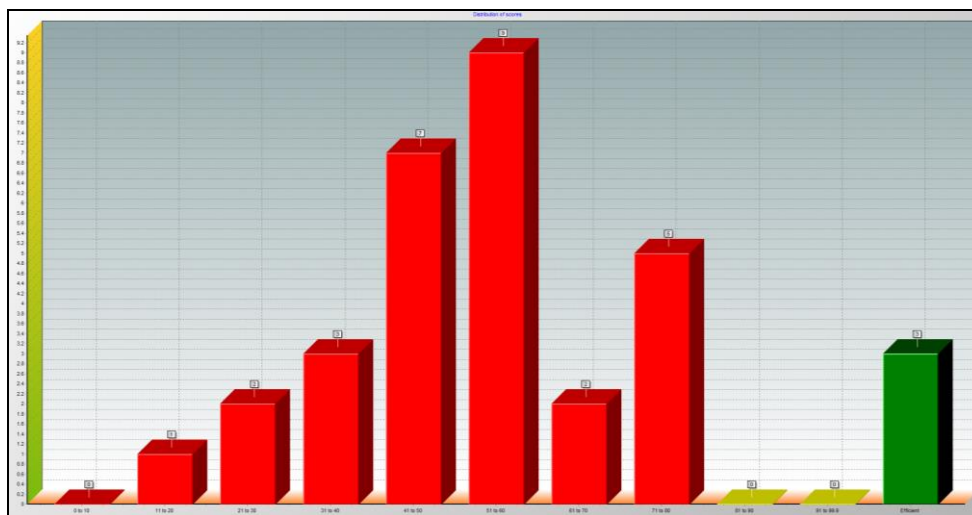
DMU's	Model 1	Model 2	Model 3	Model 4
	CRS	VRS	CRS	VRS
	One input and several outputs		Several inputs and outputs	
Aguascalientes	0.488	0.834	0.709	0.842
Baja California	0.29	0.474	0.578	0.658
Baja California Sur	0.721	1	1	1
CDMX	0.499	1	0.751	1
Campeche	1	1	1	1
Chiapas	0.712	1	0.992	1
Chihuahua	0.425	0.889	0.714	0.947
Coahuila	0.208	0.393	0.393	0.51
Colima	0.775	1	1	1
Durango	0.524	0.655	0.794	0.855
Guanajuato	0.703	1	1	1
Guerrero	0.635	0.682	0.657	0.853
Hidalgo	0.739	0.742	0.941	0.941
Jalisco	0.517	0.995	0.81	1
Michoacán	0.401	0.413	0.694	0.707
Morelos	0.508	0.508	0.702	0.703
México	0.421	1	0.713	1
Nayarit	0.536	0.674	0.65	0.674
Nuevo León	0.263	1	0.408	1
Oaxaca	0.743	0.743	0.745	0.814
Puebla	0.52	0.724	0.779	0.851
Querétaro	0.42	0.747	0.95	1
Quintana Roo	0.576	0.784	0.989	1
San Luis Potosí	0.54	0.7	1	1
Sinaloa	0.315	0.48	0.598	0.645
Sonora	0.375	1	0.586	1
Tabasco	1	1	1	1
Tamaulipas	0.434	0.644	0.585	0.644
Tlaxcala	1	1	1	1
Veracruz	0.52	0.757	0.802	0.822
Yucatán	0.527	0.644	0.806	0.821
Zacatecas	0.56	0.56	0.668	0.668

DMU's: Decision-making units.
Source: own estimate using DGIS data and MATLAB.

Table 4: Potential Improvements in models 1 and 2

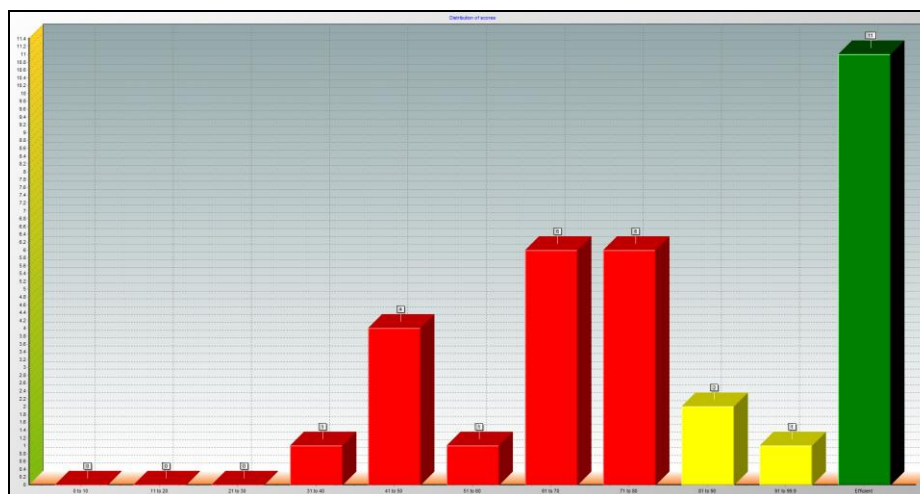
DMU's		Outputs				Input
		Outpatient visits	Length of stay	Life expectancy at birth (%)	Hospital discharges	Drug expenditure
CRS	Baja California Sur	67.14	59.00	0.00	0.00	-27.93
	Colima	51.06	50.00	0.00	21.01	-22.51
	Hidalgo	11.43	0.00	0.00	160.89	-26.11
	Oaxaca	0.00	15.94	0.00	116.04	-25.69
	Chiapas	4.66	0.55	51.75	60.72	-28.84
VRS	Jalisco	0.00	6.60	0.00	0.00	-0.53
	Chihuahua	0.00	0.00	0.00	17.01	-11.14
	Aguascalientes	18.70	0.00	0.00	31.54	-16.62

Source: Prepared by the authors using data from DGIS and Frontier Analyst-Data Envelopment Analysis Software.
DMU's: Decision-making units.



Source: Prepared by the authors using data from DGIS and Frontier Analyst-Data Envelopment Analysis Software.

Fig 3: Distribution of efficiency in model 1



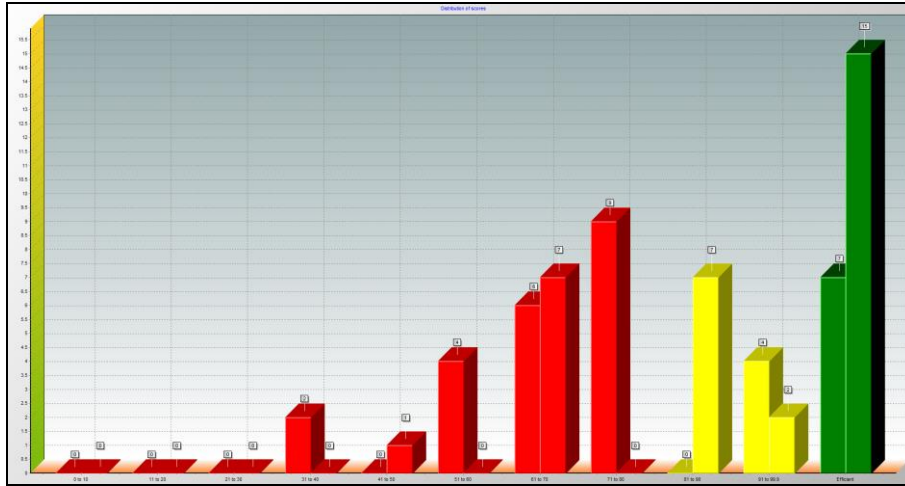
Source: Prepared by the authors using data from DGIS and Frontier Analyst-Data Envelopment Analysis Software.

Fig 4: Efficiency distribution model 2

Figure 5 shows the efficiency distribution for models 3 and 4, in which several states reach the efficient frontier: 7 DMUs under CRS (Baja California, Campeche, Colima, Guanajuato, San Luis Potosí, Tabasco, and Tlaxcala) and 15 under VRS (Baja California, Mexico City, Campeche, Chiapas, Colima, Guanajuato, Jalisco, Mexico State, Nuevo León, Querétaro, Quintana Roo, San Luis Potosí, Sonora, Tabasco, and Tlaxcala).

The states closest to achieving efficiency are six as follows:

4 DMUs under CRS (Chiapas, Hidalgo, Querétaro, and Quintana Roo) and 2 under VRS (Hidalgo and Chihuahua). Table 5 shows the potential improvements needed for these DMUs to achieve efficiency. In the case of Chiapas, to be efficient, it would need to decrease its inputs: 18.21% the number of nurses, 0.77% the spending on medicines, and 0.77% the number of doctors; or, keeping its inputs constant, it should increase its outputs: life expectancy by 39.08% and hospital discharges by 4.83%.



Source: Prepared by the authors using data from DGIS and Frontier Analyst-Data Envelopment Analysis Software.

Fig 5: Distribution of efficiency in models 3 and 4

Table 5: Potential improvements in models 3 and 4

	DMU's	Outputs				Inputs		
		Outpatient visits	Length of stay	Life expectancy at birth	Hospital discharges	Nurses	Drug expenditure	Physicians
		(%)						
Model 3 (CRS)	Chiapas	0.00	0.00	39.08	4.83	-18.21	-0.77	-0.77
	Hidalgo	12.86	0.00	0.00	101.94	-11.39	-5.95	-5.95
	Querétaro	12.73	4.52	0.00	0.00	-5.04	-57.02	-20.75
	Quintana Roo	162.49	0.00	0.00	49.06	-18.6	-30.72	-1.06
Model 4 (VRS)	Chihuahua	24.69	0.00	0.00	30.51	-35.53	-40.24	-28.63
	Hidalgo	12.86	0.00	0.00	101.94	-11.39	-5.95	-5.95

Source: Prepared by the authors using data from DGIS and Frontier Analyst-Data Envelopment Analysis Software.

From a technical standpoint, relaxing the CRS assumption increases the number of states on the efficient frontier from 3 to 11 with a single input: expenditure on medicines. The

average efficiency rises from 56% to 78% (Table 3), and a t-test indicates a highly significant difference in efficiency between models 1 and 2.

Table 6: Results of the t-test for the means of two paired samples with one input

	CRS	VRS
Mean	0.5592	0.7826
Variance	0.0408	0.0410
Observations	32	32
Pearson correlation coefficient	0.5064	--
Hypothetical difference of the means	0	--
Degrees of freedom	31	--
t-statistic	-6.2864	--
P(T<=t) one-tailed	2.72315E-07	--
Critical value of t (one-tailed)	1.6955	--
P(T<=t) two-tailed	5.4463E-07	--
Critical value of t (two-tailed)	2.0395	--

Source: own estimate using data from the General Directorate of Health Information.

Similarly, for models 3 and 4 with multiple inputs, adding the human component (doctors, nurses) and multiple products increases the number of states comprising the efficient frontier to 7 for constant returns and 15 for variable returns (see Figure 5). The average efficiency is 78% and

87%, respectively. The range of variation is smaller, and a greater number of states are close to the efficient frontier: 9 states in the VRS model. The mean test indicates that there are indeed differences in efficiency levels, with very high statistical significance (see tables 6 and 7).

Table 7: Results of the t-test for means of two paired samples with multiple inputs

	CRS	VRS
Mean	0.7817	0.8736
Variance	0.03213	0.02205
Observations	32	32
Pearson correlation coefficient	0.6627	--
Hypothetical difference of the means	0	--
Degrees of freedom	31	--

t-statistic	-3.7816	--
P(T<=t) one-tailed	0.0003	--
Critical value of t (one-tailed)	1.6955	--
P(T<=t) two-tailed	0.0007	--
Critical value of t (two-tailed)	2.0395	--

Source: own estimate using data from the General Directorate of Health Information.

Conclusion

The results show a close relationship between drug expenditure and life expectancy. Studies have found that medications account for 73% of the increase in life expectancy in some OECD member countries, including Mexico. Lichtenberg demonstrated that, had no new medications been introduced after 1981, the years of life lost before age 85 would have been 2.16 times greater [23]. The evidence suggests that purchasing medications in government hospitals increases efficiency by reducing hospitalizations and absenteeism. However, other factors, such as the quality of care provided by medical staff, also influence increases in life expectancy, as observed in models 3 and 4.

The results show a close relationship between healthcare personnel and variables such as length of stay, hospital discharges, life expectancy, and outpatient visits. Studies such as that by Liu and Eggleston [24] have found similar associations between medical personnel and increases in life expectancy and other health indicators. In the constructed DEA, healthcare personnel are key to achieving efficiency.

Other studies support the importance of medical personnel: in Poland, a lower nurse-to-patient ratio is associated with higher mortality among patients with more than 30 days of hospitalization [25]. In Finland, a lack of medical personnel increases the risk of death in patients with more complex illnesses [26]. In the United States, a higher physician density reduces mortality and increases life expectancy [27].

Our study found that incorporating medical personnel and medication expenditures was fundamental to increasing efficiency in several states that comprise the efficient frontier. By including more inputs, the model's explanation becomes more reliable, since life expectancy and other outputs depend on both medication expenditure and the interaction with human resources. The potential improvements in models 3 and 4 show that states approaching efficiency should reduce their medication expenditure or, while maintaining it, increase outpatient visits and hospital discharges. However, a more detailed analysis is required, because in Mexico some states group and concentrate the largest number of hospitals and highly specialized clinics; therefore, many of these states send their patients to cities like Mexico City, Monterrey, Guadalajara, Puebla, and Xalapa to receive specialized medical care.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Ayvar-Campos FJ, Navarro-Chávez JCL, Ramos-Arreola AR. The efficiency of health centers in Michoacan: an analysis through data envelopment. In: Critical and strategic factors in territorial interaction: current challenges and future scenery. Mexico City:

- National Autonomous University of Mexico and Mexican Association of Sciences for Regional Development AC, 2020. Retrieved from: <https://ru.iiec.unam.mx/5205/>
2. Gimenez V, Prior D, Keith JR. Strategic alliances' effects over hospital efficiency and capacity utilization in México. *Latin American Journal of Administration*,2020;33(1):128-46.
3. Suin-Guaraca LH, Feijoo-Criollo EP, Suin-Guaraca FA. Health in the territory: an approach to the Technical Efficiency of the Health System in Ecuador through Data Envelopment Analysis (DEA). *akadem*,2021;(7):130-57. Retrieved from: <https://udaakadem.uazuay.edu.ec/index.php/udaakadem/article/view/372>
4. Kamel MA, Mousa MES. Measuring operational efficiency of isolation hospitals during COVID-19 pandemic using data envelopment analysis: a case of Egypt. *Benchmarking: An International Journal*,2021;28(7):2178-2201.
5. Miszczynska K, Miszczyński PM. Measuring the efficiency of the healthcare sector in Poland – a window-DEA evaluation. *International Journal of Productivity and Performance Management*,2022;71(7):2743-70.
6. See KF, Md Hamzah N, Yu MM. Metafrontier efficiency analysis for hospital pharmacy services using dynamic network DEA framework. *Socio-Economic Planning Sciences*,2021;78:101044.
7. Pereira MA, Dinis DC, Ferreira DC, Figueira JR, Marques RC. A network Data Envelopment Analysis to estimate nations' efficiency in the fight against SARS-CoV-2. *Expert Systems with Applications*,2022;210:118362.
8. Top M, Konca M, Sapaz B. Technical efficiency of healthcare systems in African countries: An application based on data envelopment analysis. *Health Policy and Technology*,2020;9(1):62-8.
9. Zhou L, Ampon-Wireko S, Dauda L, Xu X, Antwi MO, Larnyo E. Empirical Analysis of Factors Influencing Healthcare Efficiency among Emerging Countries. *Healthcare (Basel)*,2021;9(1):31.
10. DGIS. Health Information System, 2025. Obtained from Query Boards: <https://sinaiscap.salud.gob.mx/DGIS>
11. OECD Health Statistics, 2026. Retrieved from: <https://www.oecd.org/en/data/datasets/oecd-health-statistics.html>
12. Mexican Government. Available from: Presidency of the Republic, 2026. Blog: <https://www.gob.mx/presidencia/articulos/version-estenografica-conferencia-de-prensa-de-la-presidenta-claudia-sheinbaum-pardo-del-20-de-enero-de-2026>
13. INEGI. National Institute of Statistics and Geography, 2026. Available from: Life expectancy at birth by federal entity according to sex, Annual series from 2010 to 2026:

- https://www.inegi.org.mx/app/tabulados/interactivos/?pxq=Mortalidad_Mortalidad_09_db78b87b-1e13-46d9-9adf-9c29fe345276
14. Funsalud. Mexico Health Indicators Dashboard. Mexico Health Sector, 2023. Available from: <https://funsalud.org.mx/wp-content/uploads/2023/11/Tablero-de-indicadores-S-FVv1.pdf>
 15. Charnes A, Cooper WW, Rhodes E. Measuring the efficiency of decision making units. *Eur J Oper Res*,1978;2(6):429-44.
 16. Farrell MJ. The Measurement of Productive Efficiency. *J R Stat Soc Ser A*,1957;120(3):253-81.
 17. Front Matter. *Management Science*, 1984, 30(9). JSTOR, Retrieved from: <http://www.jstor.org/stable/2631721>.
 18. Banker RD, Charnes A, Cooper WW. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science*,1984;30(9):1078-92. <http://www.jstor.org/stable/2631725>.
 19. Charnes A, Rousseau J. Sensitivity and Stability of Efficiency Classifications in Data Envelopment Analysis. *J Prod Anal*,1996;7(1):5-18.
 20. Banker RD, Charnes A, Cooper WW. Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Manage Sci*,1984;30(9):1078-92.
 21. Alvarez IC, Barbero J, Zofío JL. A Data Envelopment Analysis Toolbox for MATLAB. *J Stat Softw*,2020;95(3):1-49.
 22. Alvarez IC, Barbero J, Zofío JL. A data envelopment analysis toolbox for MATLAB. *Journal of Statistical Software*,2020;95:1-49. Retrieved from: <https://www.jstatsoft.org/index.php/jss/article/view/v095i03>
 23. Weber Foundation. The value of medicine from a social perspective 2024. Madrid: Weber Foundation, 2024.
 24. Liu J, Eggleston K. The Association between Health Workforce and Health Outcomes: A Cross-Country Econometric Study. *Soc Indic Res*,2022;163(2):609-32.
 25. Malinowska-Lipień I, Put D, Maluchnik M, Gabryś T, Kózka M, Gajda K, *et al*. Influence of the work environment of nurses on the 30-day mortality of patients hospitalized in Polish hospitals. cross-sectional studies. *BMC nursing*,2024;23(1):117.
 26. Peutere L, Pentti J, Ropponen A, Kivimäki M, Härmä M, Krutova O, *et al*. Association of nurse understaffing and limited nursing work experience with in-hospital mortality among patients: A longitudinal register-based study. *Int J Nurs Stud*,2024;150:104628.
 27. Haggstrom DA, Bair MJ. Primary Care and Survival: Implications for Research and Policy. *Journal of General Internal Medicine*, 2026, 1-3.