

Economic impact of timely diagnosis and early referral in comprehensive cancer care in Mexico: the DERIVA strategy

Óscar Arrieta, MSc,⁽¹⁾ Ana Pamela Gómez-García, PhD,⁽¹⁾ Karla Adriana Espinosa-Bautista, MD,⁽²⁾ Juan Gabriel Gay-Molina, MD,⁽³⁾ Luis Adrián Ortiz-Blas, Econ,⁽³⁾ Claudia Haydée Arce-Salinas, MD,⁽⁴⁾ Héctor Martínez-Saíd, Oncol Surg,⁽⁵⁾ Héctor Valle-Mesto, BA,⁽⁶⁾ Nancy Reynoso-Noverón, PhD.⁽⁷⁾

Arrieta Ó, Gómez-García AP, Espinosa-Bautista KA, Gay-Molina JG, Ortiz-Blas LA, Arce-Salinas CH, Martínez-Saíd H, Valle-Mesto H, Reynoso-Noverón N.

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Abstract

Objective. To estimate the savings of a strategy for early diagnosis and treatment of patients with suspected cancer. **Materials and methods.** A financial analysis of the savings was carried out using a timely diagnostic program DERIVA. Cancers with higher mortality in Mexico were evaluated under three scenarios of earlier stage diagnosis. Optimistic: stage III to II (8-40%) and IV to III (2.6-40%). Moderate: stage III to II (4-24%) and IV to III (1.3-24%). Conservative: stage III to II (1-7%) and IV to III (0.7-10%). **Results.** Care in stage II is projected to increase by 13.85% for breast cancer and 5.13% for colorectal cancer; while stage III care for lung cancer is expected to rise by 14.1%. The estimated average savings amount to 4 106 834.94 ± 6 467 043.35 USD. **Conclusion.** Early detection and treatment of certain types of cancer can lead to significant cost savings, contributing to the financial sustainability of the health system and to improved survival rates and quality of life for patients.

Keywords: barriers; delays; cancer care; cancer detection and diagnosis; early diagnosis

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Resumen

Objetivo. Estimar el ahorro económico derivado de una estrategia de diagnóstico y tratamiento precoz oportuno en pacientes con sospecha de cáncer. **Material y métodos.** Se realizó un análisis financiero del ahorro implementando un programa de diagnóstico oportuno DERIVA. Se consideraron los cánceres con mayor mortalidad en México evaluando diferentes escenarios de desplazamiento hacia etapas más tempranas al momento del diagnóstico: escenario optimista: desplazamiento de etapa III a II (8-40%) y de etapa IV a III (2.6-40%), escenario moderado: desplazamiento de etapa III a II (4-24%) y de etapa IV a III (1.3-24%) y escenario conservador: desplazamiento de etapa III a II (1-7%) y de etapa IV a III (0.7-10%). **Resultados.** En el escenario optimista se proyecta un aumento en la proporción de atención en etapa II de 13.85% para cáncer de mama y 5.13% para cáncer colorrectal; para cáncer de pulmón se estima un aumento de 14.1% en la etapa III. Los ahorros promedio estimados ascienden a 4 106 834.94 ± 6 467 043.35 USD. **Conclusión.** La detección y el tratamiento oportuno de ciertos tipos de cáncer pueden generar ahorros económicos significativos, contribuyendo a la sostenibilidad financiera del sistema de salud y a mejores tasas de supervivencia y calidad de vida para los pacientes.

Palabras clave: barreras; retrasos; atención del cáncer; diagnóstico precoz

- (1) Unidad Funcional de Oncología Torácica, Instituto Nacional de Cancerología. Mexico City, Mexico.
- (2) Coordinación de los Hospitales Regionales de Alta Especialidad. Mexico City, Mexico.
- (3) Tecnología e Información para la Salud. Mexico City, Mexico.
- (4) Departamento de Oncología, Instituto Nacional de Cancerología. Mexico City, Mexico.
- (5) Subdirección de Cirugía, Instituto Nacional de Cancerología. Mexico City, Mexico.
- (6) Fundación Mexicana para la Salud. Mexico City, Mexico.
- (7) Dirección de Investigación, Instituto Nacional de Cancerología. Mexico City, Mexico.

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Corresponding author: Oscar Arrieta. Instituto Nacional de Cancerología. 22 San Fernando Av, Belisario Domínguez Sec 16. 14080 Tlalpan, Mexico City, CDMX. email: ogarrieta@gmail.com

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Cancer is a leading cause of death globally. In 2022, there were 207 154 new cases and 96 210 deaths reported in Mexico.^{1,2} Nowadays, incidence and mortality rates are 140.9 and 63.5 per 100 000 inhabitants, respectively. Malignant tumors ranked third among causes of death in 2023 (10.57%) and accounted for 11.37% in early 2024.³⁻⁵ Early detection improves survival, reduces treatment burden, and lowers healthcare costs.^{6,7}

In middle-income countries (MIC) like Mexico, delays in diagnosis and treatment are linked to poor outcomes and higher costs.^{8,9} Effective cancer control must include timely diagnosis and treatment, palliative care, navigation, and psychosocial support.^{10,11} However, although high-income countries (HICs) like the United Kingdom (UK) demonstrate cost-saving outcomes with early diagnosis and established timelines,^{12,13} Mexico still faces frequent late-stage diagnoses.¹⁴ Social determinants such as economic status, education, and healthcare access impact cancer outcomes.^{15,16} A survey in Mexico City public hospitals showed that younger, poorer, and non-local patients reported more barriers to care.¹⁷

Fragmented systems and resource gaps lead to delays, higher mortality, and financial toxicity, especially among the uninsured.^{9,17-21} Faster diagnosis-to-treatment timelines improve outcomes and reduce costs. International experiences (from teledermatology in Australia²² to UK reforms²³ and training in Brazil²⁴ show positive impacts. In contrast, in Mexico only 13.8% of breast cancer cases are diagnosed at stage I.^{17,25} In 2019, treatment costs for colorectal cancer varied by country and disease stage: from a lifetime cost of \$56 736.10 USD in Norway to an annual average of \$5 745.29 USD in Iran.^{26,27} In Mexico, the annual cost per breast cancer patient averaged \$9 509.44 USD.²⁸ Despite this, cancer's economic impact in Latin America remains understudied.²⁹

Timely referral from primary and secondary care to tertiary care is essential but limited by infrastructure and personnel. DERIVA (for its acronym in Spanish: *Detección y Referencia Inmediata para la Valoración Avanzada del Cáncer*) aims to reduce delays and align care with international standards through the integration of specialized cancer diagnosis and referral centers into public and private hospitals. Initial focus will be on high-burden cancers (e.g., breast, cervical, lung) through a multidisciplinary approach.³⁰ The proposal will integrate, in addition, confirmatory testing (with the use of genetic tests when necessary), navigators to support patients through financial, cultural, and bureaucratic barriers,³¹⁻³³ working with healthcare teams to ensure timely access to care. Therefore, this study aimed to estimate the direct medical savings per patient diagnosed with one of the five cancers with the highest incidence and mortality in Mexico, and according to the stage of the disease.

Materials and methods

Study design

We conducted a cost analysis to estimate the direct medical savings associated with the implementation of DERIVA in Mexico (supplementary table 1, and supplementary figures 1 and 2).³⁴ The analysis was based on three hypothetical scenarios: optimistic, moderate, and conservative; and relied on secondary data sources. Medical costs were compared between the current standard of care and a proposed pathway involving earlier diagnosis and treatment.

Population and cancer types

The study focused on five cancer types with the highest incidence and mortality rates in the Mexican population: lung, breast, cervical, prostate, and colorectal cancers. Incidence data were obtained from high-impact scientific publications.³⁵ Information on stage at diagnosis was drawn from the *Instituto Nacional de Estadística y Geografía* (INEGI), local cancer registries, and peer-reviewed literature. When specific data were unavailable, estimates from the Ministry of Health and the Global Cancer Observatory (GCO), part of the International Agency for Research on Cancer (IARC), were used.^{36,37}

Economic analysis of the DERIVA strategy

Stage-specific distribution data were extracted from peer-reviewed studies and institutional reports, compiled by technical experts from major public healthcare institutions in Mexico. Cost estimates were based on official price lists from institutions such as the *Instituto Mexicano del Seguro Social* (IMSS), the Ministry of Health (SS), and the *Instituto Nacional de Cancerología* (INCan), and were supplemented by academic literature on cancer care costs.^{35,38,39} Average annual direct treatment costs by stage and tumor type were obtained from the literature.^{35,40-44}

When specific data were not available, Diagnosis-Related Groups (DRG) methodology was applied.⁴⁵ In addition, cost references from the Catastrophic Health Expenditures Fund of the Social Protection System in Health (2019) were used. All costs were calculated in Mexican pesos (MXN) and adjusted to 2024 values using the National Consumer Price Index (INPC), as published by INEGI. Costs were then converted to US dollars (USD) using the average exchange rate for December 2024, according to the Bank of Mexico's historical exchange rate data. Inflation adjustments were performed using INEGI's official inflation calculator.⁴⁶

Costs were further adjusted using stage-specific transition probabilities published for each cancer type.^{2,11,47-50}

Annualized costs were considered within a one-year time horizon. The analysis was conducted from the perspective of the public healthcare system, including only direct medical costs. Where two cost estimates were available for a given parameter, a mean value was calculated to generate a single reference cost.

Development of the economic model

To develop the economic model, we reviewed analytical frameworks used in similar health programs.^{51,52} For each cancer type and over a defined period, patients were distributed across the four clinical stages (figure 1). It was assumed that the DERIVA strategy would reduce diagnoses at advanced stages and lower associated treatment costs by at least 10%. Additionally, we assumed that 50% of patients diagnosed with cancer would receive treatment, which informed the projected number of treated individuals per cancer type.

Analysis of economic impact

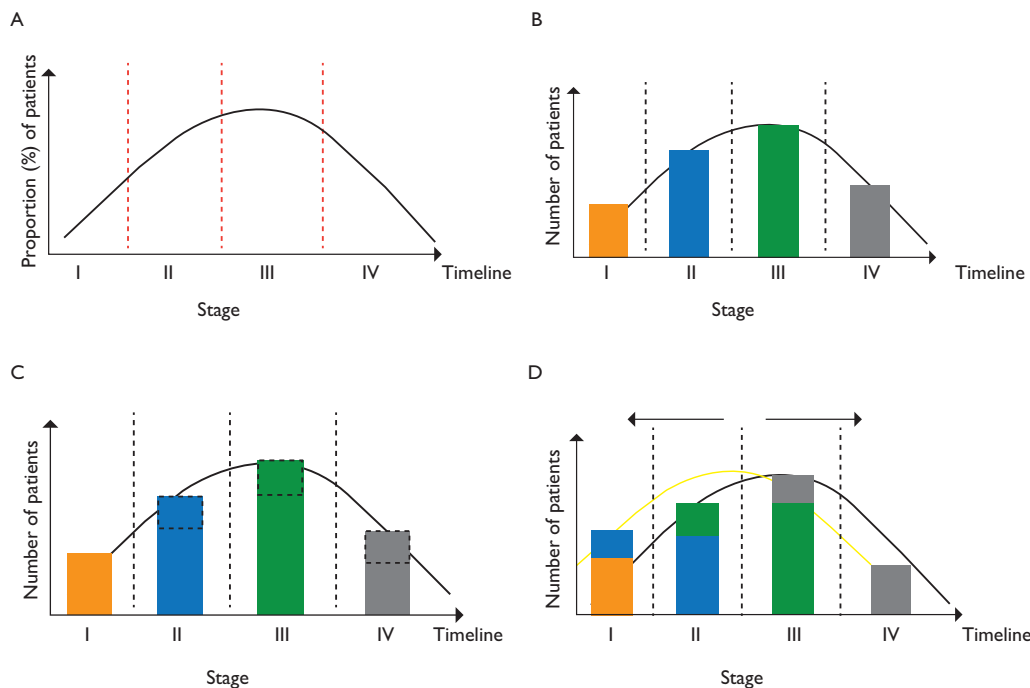
We used the most recent national data on the annual distribution of cancer patients to simulate the propor-

tion of cases that could be diagnosed at an earlier stage. Three scenarios (optimistic, moderate, and conservative) were modeled to estimate the percentage of patients who would benefit from earlier diagnosis. A sensitivity analysis was conducted by varying these percentages across scenarios to estimate the difference (i.e., the projected savings) in total treatment costs with and without implementation of the DERIVA program.

Results

Patients treated at each disease stage

After estimating the proportion of patients treated at each disease stage across the hypothetical scenarios, these proportions were compared with the current national treatment distribution. In the optimistic scenario, increases of 1.26, 13.85, and 5.13% were observed in Stage II treatment rates for lung, breast, and colorectal cancers, respectively. Additionally, Stage III treatment for lung cancer increased by 14.1%. In the moderate scenario, Stage II treatment rates increased by 8.31% for breast cancer and 4.16% for colorectal cancer, while Stage III lung cancer treatment increased by only 1.42%. No increases in treatment proportions were observed in the conservative scenario (table I).



A) Distribution of patients by cancer stage across all analyzed tumor types; B) Baseline distribution of patients at each disease stage in the current scenario (without DERIVA); C) Estimated proportion of patients who would benefit from DERIVA, indicated by the dotted boxes within each cancer stage; D) Adjusted patient distribution per cancer stage after applying the projected stage shift resulting from early diagnosis and timely referral under the DERIVA scenario

FIGURE 1. PATIENT DISTRIBUTION BY CANCER STAGE AND ECONOMIC ANALYSIS SCENARIO

Table I
PERCENTAGE OF PATIENTS WHO RECEIVE CARE AT EACH STAGE OF THE DISEASE
CONSIDERING THE CURRENT CARE SCENARIO IN MEXICO AND THREE HYPOTHETICAL
SCENARIOS FOR EARLY CARE FOR EACH OF THE NEOPLASMS

Cancer type	Patients with care (%) for each stage in the current scenario			
	I	II	III	IV
Lung	12.13	8.25	15.65	63.96
Breast	13.10	39.0	34.63	13.27
Cervicouterine	14.10	44.87	33.33	7.69
Prostate		53.80	13.40	32.80
Colorectal	2.33	55.81	24.42	17.44
Cancer type	Patients with care (%) per stage in an optimistic scenario			
	I	II	III	IV
Lung	12.13	9.51*	29.75*	48.61
Breast	13.10	52.85*	26.09	7.26
Cervicouterine	14.10	44.87	34.72	6.31
Prostate		53.80	14.25	31.95
Colorectal	2.33	60.94*	22.95	13.78
Cancer type	Patients with care (%) for each stage in moderate scenario			
	I	II	III	IV
Lung	12.13	8.88	17.07*	61.91
Breast	13.10	47.31*	29.51	10.09
Cervicouterine	14.10	44.87	34.03	7.0
Prostate		53.80	13.83	32.37
Colorectal	2.33	59.97*	22.36	15.35
Cancer type	Patients with care (%) for each stage in conservative scenario			
	I	II	III	IV
Lung	12.13	8.44	16.23	63.19
Breast	13.10	41.42	33.54	11.94
Cervicouterine	14.10	44.87	33.68	7.35
Prostate		53.80	13.63	32.57
Colorectal	2.33	56.67	24.17	16.83

Notes: Data are reported in frequencies (%).

* Increase of $\geq 1\%$ in the management of five neoplasms according to disease stage, for the optimistic, moderate, and conservative scenarios.

Earlier stage diagnosis of patients

Estimations of patients with various neoplasms who could potentially be diagnosed at an earlier stage through timely intervention under the DERIVA program revealed that, in the optimistic scenario, 8 to 40% of Stage III patients could be reclassified to Stage II. This potential reduction ranged from 4 to 24% in the moderate scenario, and from 1.2 to 7% in the conservative scenario. Similarly, between 2.6 and 40% of Stage IV patients could be reclassified to Stage III under the optimistic scenario;

between 1.3 and 24.0% in the moderate; and between 0.7 and 10% in the conservative scenario (table II).

Cost calculation and savings from DERIVA implementation

Using the estimated treatment proportions by stage, total costs were calculated both with and without the DERIVA program implementation. The intervention resulted in an average overall cost reduction of USD 4 106 834.94 \pm 6 467 043.35 (median USD 1 306 694.01;

Table II
ESTIMATED PERCENTAGE OF PATIENTS MOVING TO A PRE-CANCER STAGE IN ALL
THREE SCENARIOS ACCORDING TO THE PROPOSED DERIVA

Cancer type	Optimistic		Moderate		Conservative	
	III to II	IV to III	III to II	IV to III	III to II	IV to III
Lung	8.0	24.0	4.0	3.2	1.2	1.2
Breast	40.0	40.0	24.0	24.0	7.0	10.0
Cervicouterine		18.0		9.0		4.5
Prostate		2.6		1.3		0.7
Colorectal	21.0	21.0	17.0	12.0	3.5	3.5

Notes: Data are reported in frequency (%). Data for stage II to I replacement, in each scenario, are not shown because no changes were observed.

IQR 166 562.27-4 002 003.38). In the optimistic scenario, the largest savings were observed in lung cancer, amounting to USD 22 751 401.46. For breast cancer, the moderate and conservative scenarios yielded estimated savings of USD 8 533 620.51 and USD 2 731 096.96, respectively (table III).

Discussion

The rising incidence of cancer in Mexico presents a significant challenge that demands progress in disease control to achieve survival rates comparable to those in high-income countries. Early detection plays a crucial role in this endeavor, offering a more cost-effective strategy for cancer management over time.

This concern is highlighted by a study conducted in Mexico City that demonstrated a strong correlation between healthcare system delays and advanced clinical stages of breast cancer at diagnosis, with 45% of patients presenting at stages III and IV.⁵²⁻⁵⁴ Similar patterns have been reported in countries such as Brazil, Egypt, India, Libya, Nigeria, Peru, and Thailand.⁵⁵ In contrast, high-income countries like Norway, Sweden, and the United Kingdom report only 8-20% of cancers diagnosed at late stages.¹⁸ Additionally, the average diagnostic delay for childhood cancers in Mexico is 40 days, compared to just 7-8 days in countries like Canada and Italy.²¹

Bright and collages evaluated the Mexican healthcare system's role in delaying breast cancer diagnosis and treatment at a Mexico City hospital, documenting an average diagnostic delay of 7.8 months, with patients undergoing approximately 7.9 consultations before definitive diagnosis, and an 8.4-month delay before treatment initiation.⁵⁶ Such extensive delays contribute to late-stage diagnoses, which not only reduce survival but also increase treatment complexity and costs, while negatively impacting quality of life.

According to data from the INCan, 82% of lung cancer cases are diagnosed with metastasis, and only 1.2% at early stages (I-II). Early-stage treatments are costly, but treatment for advanced disease (stages III-IV), mainly chemotherapy-based, can exceed USD 140 000 annually, excluding targeted and immunotherapies.²⁰ These figures underscore the urgent social and economic necessity for early diagnosis and timely referral programs like DERIVA.

It is important to note that the financial estimates presented here cannot be generalized due to patient- and disease-specific variability. A major limitation is the scarcity of publicly available, disaggregated cost data in the Mexican healthcare system. Moreover, lack of robust data on disease natural history, such as transition times between stages without intervention and delays to diagnosis or treatment, introduces uncertainty in modeling the time windows when medical care has the greatest impact, especially when comparing DERIVA participants to non-participants. To address this, three scenarios (optimistic, moderate, and conservative) were developed as approximations of patient stage transitions.

Nonetheless, even under conservative assumptions, the projected financial savings would be clinically meaningful and economically impactful. Savings generated could be reinvested in primary, secondary, and tertiary cancer prevention, strengthening strategies for health promotion, specific protection, early diagnosis, timely treatment, damage mitigation, and rehabilitation –all of which contribute to improved survival and quality of life–.

Beyond the healthcare system, the financial burden of cancer care extends to families, often resulting in catastrophic expenses for those without social security coverage. Thus, even modest savings from DERIVA could enhance financial protection for vulnerable popu-

Table III
CURRENT AND ESTIMATED COSTS OF IMPLEMENTING THREE SCENARIOS OF THE CANCER CODE STRATEGY IN THE CARE OF FIVE CANCERS WITH HIGH INCIDENCE AND MORTALITY IN THE COUNTRY

Cancer type	No strategy	With strategy	Estimated savings
Optimist scenario			
Lung	270 109 393.57	247 357 992.12	22 751 401.46
Breast	177 003 906.26	162 781 205.41	14 222 700.86
Cervicouterine	51 244 902.56	50 578 653.48	666 249.08
Prostate	136 041 183.19	135 998 309.92	42 873.27
Colorectal	93 188 381.23	89 186 377.84	4 002 003.38
Total	727 587 766.81	685 902 538.76	41 685 228.05
Overall saving		8 337 045.61 ± 9 859 533.42 4 002 003.38 [354 561.18 – 18 487 051.16]	
Moderate scenario			
Lung	270 109 393.57	266 455 752.26	3 653 641.31
Breast	177 003 906.26	168 470 285.75	8 533 620.51
Cervicouterine	51 244 902.56	50 911 778.02	333 124.54
Prostate	136 041 183.19	136 019 746.55	21 436.63
Colorectal	93 188 381.23	90 695 804.72	2 492 576.51
Total	727 587 766.81	712 553 367.31	15 034 399.51
Overall saving		3 006 879.90 ± 3 438 368.41 2 492 576.51 [177 280.59 – 6 093 630.91]	
Conservative scenario			
Lung	270 109 393.57	268 802 699.56	1 306 694.01
Breast	177 003 906.26	174 272 809.30	2 731 096.96
Cervicouterine	51 244 902.56	51 078 340.29	166 562.27
Prostate	136 041 183.19	136 029 640.38	11 542.80
Colorectal	93 188 381.23	92 521 380.67	667 000.56
Total	727 587 766.81	722 704 870.20	4 882 896.62
Overall saving		976 579.32 ± 1 103 468.39 667 000.56 [89,052.54 - 2 018 895.49]	
Average overall savings for all three scenarios		4 106 834.94 ± 6 467 043.35 1 306 694.01 [166,562.27 - 4 002 003.38]	

Notes: Data are reported in US dollars (USD) values in December 2024, and presented in mean, standard deviation, and median (interquartile range, Q1-Q3).

lations and fund broader community-focused oncological interventions with significant social impact.

Conclusions

The timing of cancer diagnosis within the Mexican health system, along with disparities in care across the population, is concerning. Implementing a program that reduces treatment delays and improves clinical outcomes has the potential to significantly lower the high costs associated with late-stage cancer treatment. DERIVA aims to reduce the financial burden of treating lung, breast, cervical, prostate, and colorectal cancers

by promoting early diagnosis through timely detection tools and prompt referral, recognizing that treatment costs escalate with advancing disease stage.

The implementation of a strategy like DERIVA will benefit patients by ensuring timely and effective medical care and will strengthen the healthcare system by focusing medical services not only on reducing the lengthy referral wait times to tertiary care centers, which can be as long as seven months, but also on substantially decreasing disparities in access and care across the population. Patient navigation will play a key role within this strategy, facilitating comprehensive access to screening, diagnosis, and treatment services at all

care levels. Importantly, this program is designed not to impose additional burdens on existing healthcare personnel but to optimize the use of current resources within the healthcare system.

Credit statements

Conceptualization: O.A. Methodology: APG-G, JGG-M, NR-N, LAO-B. Validation: JGG-M, LAO-B. Formal analysis: JGG-M, LAO-B. Investigation: APG-G, JGG-M, NR-N, LAO-B, KAE-B, HM-S, CHA-S. Resources: APG-G, NR-N, KAE-B, CHA-S, HM-S, HV-M. Data curation: JGG-M, LAO-B. Writing – original draft: APG-G. Writing – review & editing: APG-G, NR-N. Visualization: APG-G, NR-N. Supervision: O.A, KAE-B, CHA-S, HM-S, NR-N. Project administration & Funding acquisition: O.A. All authors participated equally in the manuscript's conceptualization, research, and writing. All authors have read and approved the latest version of the work manuscript.

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Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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