EE156

Modeling the Potential Public Health Impact and Cost-effectiveness of BNT162b2 COVID-19 Vaccination Booster in Costa Rica

Juan José Baldi-Castro[1], Carlos Fernando Mendoza[2], Moe H Kyaw[3], Iustina Chirila[4], Leo Alejandro Barrantes[1], Elena Aruffo[5], Ben Yarnoff[6], Karen Villamil-Herrera[1], Marcel Marcano-Lozada[1]

[1]Pfizer Central America and the Caribbean, Escazú, Costa Rica; [2]Pfizer Inc., CDMX, Mexico; [3]Pfizer Inc., Collegeville, PA, USA; [4]Pfizer Ltd, Tadworth, UK; [5]Thermo Fisher Scientific, Milan, Italy; [6]Thermo Fisher Scientific, Waltham, MA, USA

INTRODUCTION

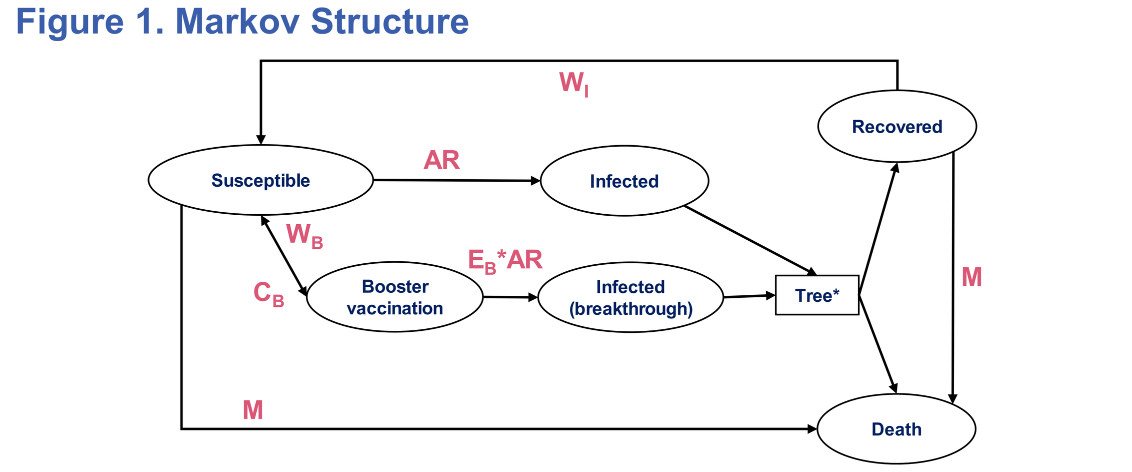
- By March 15, 2025, COVID-19, caused by the SARS-CoV-2 virus, had led to around 777 million cases and 7 million deaths worldwide, with approximately 1.2 million cases and almost 9,400 deaths reported in Costa Rica.[1]
- Although COVID-19 has become endemic, it continues to circulate in Latin America and the Caribbean[2] and imposes considerable economic costs on the national healthcare system in Costa Rica.[3]
- By December 2023, approximately 13.58 million COVID-19 vaccine doses had been administered in Costa Rica. About 86% of the population has completed the primary series of a COVID-19 vaccine, and 59% of the population has received at least one booster dose.[1] Nevertheless, the protection conferred by COVID-19 vaccines has been observed to wane over time, and newer variants and sublineages of SARS-CoV-2 have emerged—BA.2.86 and JN.1 were the latest variants in circulation as of June 2024.[4,5]
- To address the rapidly evolving nature of SARS-CoV-2 and the emergence of new variants, the WHO formed the Technical Advisory Group on COVID-19 Vaccine Composition. This group advises on new formulations of COVID-19 vaccines to help mitigate the spread of SARS-CoV-2 variants.[6] In Costa Rica, BNT162b2 COVID-19 (COMIRNATY) received regulatory approval in March 2024 (XBB.1.5). The COMIRNATY JN.1 vaccine is anticipated to receive approval in 2025.
- This modeling study evaluated the economic and health impacts of administering BNT162b2 COVID-19 annually with an adapted[a] COVID-19-booster vaccine[7] from both a public payer and societal perspective in Costa Rica.

[a]The BNT162b vaccine initially included mRNA from the original SARS-CoV-2 virus. As new variants with different proteins have emerged, BioNTech and Pfizer have developed updated versions of the BNT162b vaccine that incorporate mRNA from specific variants, referred to as variant-adapted COVID-19 mRNA vaccines. Updated vaccines may include variant mRNA along with or instead of the original virus mRNA.[7]

METHODS

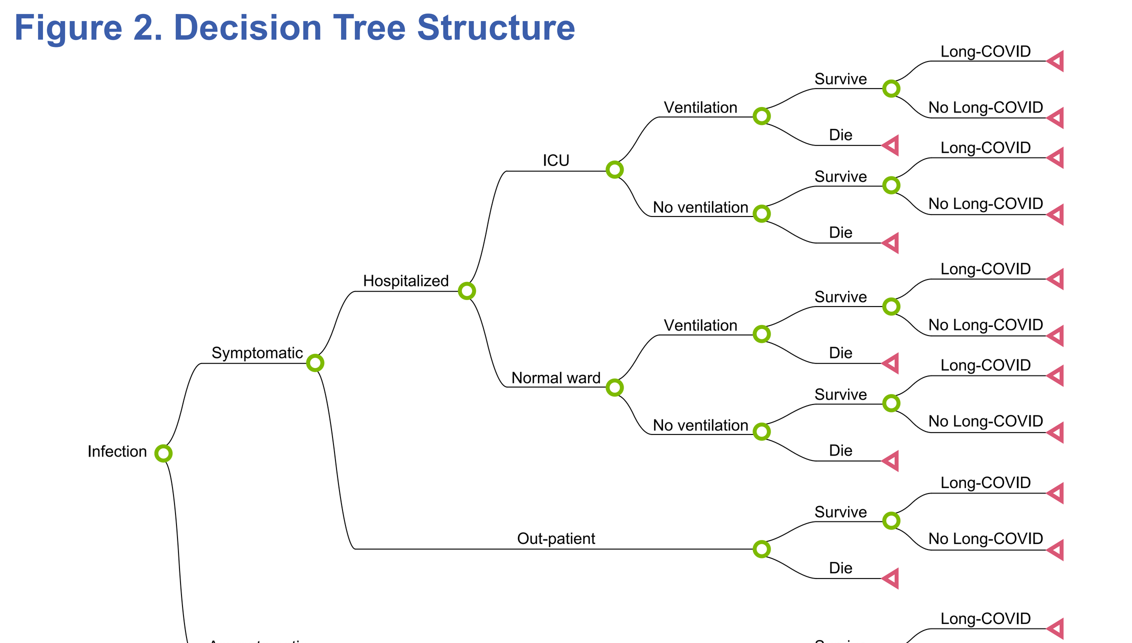
- An existing economic model for COVID-19 (a Markov cohort decision tree model)[8] was adapted specifically for the Costa Rican context to evaluate the economic and health implications of using an adapted vaccine in the country, targeting various age groups over a 1-year time horizon, considering an adjusted eligible population of individuals aged ≥65 years and high-risk individuals aged 18–64 years (n=794,546) as part of the base case.
- The Markov component of the model tracked the target population through distinct and mutually exclusive states using a Susceptible-Infected-Recovered framework from previous disease transition modeling studies,[9-12] as illustrated in **Figure 1**. The decision tree component modeled the various levels of disease severity and treatment pathways (e.g., outpatient, inpatient, ICU) and their associated outcomes, as shown in **Figure 2**.

Figure 1. Markov Structure



W_B: waning post booster; AR: attack rate; E_B: efficacy post booster
W_I: waning of infection-induced immunity; C_B: booster coverage; M: background mortality
* From each infected state patients will transition to a decision tree each with the same structure but different probabilities

Figure 2. Decision Tree Structure



Abbreviations: ICU = intensive care unit

METHODS (cont.)

Inputs

- Epidemiological model inputs were sourced from the Costa Rica Ministry of Health or from published literature and are summarized in **Table 1**.
- Real-world evidence informed the vaccine profile used in the model,[13-20] with effectiveness rates of 50% for infections, 60% for symptomatic infections, and 70% for hospitalization. The duration of vaccine protection was set at 6 months. It was assumed that immunity resulting from infection lasts for 3 months.
- The model accounted for the probability of complications in the high-risk population by using risk ratios for increased hospitalization, severe COVID-19 requiring ICU care, and mortality.[21]
- Inpatient and outpatient treatment costs and length of stay for inpatient treatment were sourced from a local study.[3] Long COVID treatment costs were based on assumptions of four COVID-19 tests, four general practitioner visits, one specialist visit, and a 17% probability of being hospitalized.[22] Vaccine acquisition costs per dose were obtained from the Pan American Health Organization´s revolving fund.[23] COVID-19-specific vaccine administration costs per dose were obtained from an institutional tariff from the primary public healthcare provider in Costa Rica.[24]
- The indirect costs of productivity losses related to COVID-19 and long COVID were estimated from a societal perspective. Workforce participation rates were obtained from the Costa Rica Statistics Bureau.[25] Weekly labor costs were estimated using the percentage increase by years of experience from Mexico and the average Costa Rican salary for 2023.[26,27] The number of working days lost to COVID-19 and long COVID was sourced from the Centers for Disease Control and relevant literature.[28,29]
- Inputs for QALYs were sourced from the literature.[30-35]
- This study used a 3% discount rate for costs and health effects.[30]
- All costs were either expressed in 2024 USD or inflated to 2024 USD.

Table 1. Epidemiology and Clinical Inputs

Input Description	18–29 Years	30–49 Years	50–64 Years	65–74 Years	≥75 Years	References
Population size 2024 (thousands)	963.1	1575.2	821.5	353.4	222.6	Costa Rica Statistics Bureau[36]
Proportion at high risk	1.07%	3.51%	8.24%	13.29%	17.21%	Clark et al.[37]
Annual attack rate	30.44%	29.28%	21.80%	12.09%	12.80%	Costa Rica Ministry of Health. The attack rate was estimated using data from 2022,[38,39] applying an underreporting factor of 146.3 from Colombia as proxy from Mustapha et al.[40]
Probability that infection is symptomatic	67.90%	67.90%	67.90%	80.30%	80.30%	Sah et al.[41]
Proportion of symptomatic patients (medically attended) who are hospitalized	0.08%	0.14%	0.38%	0.68%	1.21%	Costa Rica Ministry of Health[38,39]
Proportion of hospitalized patients admitted to ICU	0.17%	0.20%	0.28%	0.42%	0.42%	Mexico from Ascencio-Montiel et al. [21] Costa Rica Ministry of Health[38]
Proportion of ICU patients on mechanical ventilation	71%	71%	71%	71%	71%	Augustovski et al.[30]
Probability of death among patients on normal ward without ventilation	0.16%	1.26%	2.70%	2.20%	3.87%	Costa Rica Ministry of Health[38,39]
Probability of long COVID – Vaccinated	12.32%	14.62%	14.55%	13.86%	15.47%	Angarita-Fonseca et al.[22]
Probability of long COVID – Susceptible	16.42%	19.50%	19.40%	18.48%	20.63%	

Abbreviation: ICU = intensive care unit

RESULTS

- Compared with no vaccination, the vaccination strategy targeting older adults aged ≥65 years and high-risk individuals aged 18–64 years was projected to avert 3,245 symptomatic cases, 3,215 outpatient cases, 30 hospitalizations, 89 lost QALYs, and one death, yielding an incremental direct cost decrease of USD 8,314,290 and incremental total societal cost savings of USD 9,309,851 (**Table 2**).
- Compared with no vaccination, the alternative vaccination strategy (vaccinating individuals aged ≥60 years and high-risk individuals aged 18–59 years) averted 5,100 symptomatic cases, 5,062 outpatient cases, 38 hospitalizations, 141 lost QALYs, and one death, yielding an incremental direct cost decrease of USD 13,553,757 and incremental total societal cost savings of USD 15,648,147 (**Table 2**).

RESULTS (cont.)

Table 2. Results of COVID-19 Vaccine vs. No Vaccination

		Aged ≥65 Years and High-risk Individuals Aged 18–64 Years		Aged ≥60 Years and High-risk Individuals Aged 18–59 Years	
Outcome	**No Vaccination**	**COVID-19 Vaccination**	**Incremental Difference**	**COVID-19 Vaccination**	**Incremental Difference**
Total population	5,164,860	5,164,860	0	5,164,860	–
Doses administered	0	114,350	114,350	160,944	160,944
Health outcomes					
Symptomatic cases	747,564	744,320	-3,245	742,465	-5,100
COVID-19-related deaths	35	34	-1	34	-1
Outpatient cases	745,897	742,682	-3,215	740,835	-5,062
Hospitalizations	1,667	1,637	-30	1,629	-38
Discounted QALYs lost	17,225	17,136	-89	17,084	-141
Economic outcomes					
Vaccine acquisition	–	$2,058,299	$2,058,299	$2,896,994	$2,896,994
Vaccine administration	–	$481,413	$481,413	$677,575	$677,575
AE management cost	–	$43,691	$43,691	$61,494	$61,494
Long COVID treatment costs	$323,384,211	$321,990,957	-$1,393,255	$321,075,132	-$2,309,080
Inpatient treatment cost	$14,561,801	$14,281,868	-$279,932	$14,204,474	-$357,326
Outpatient treatment cost	$2,140,088,306	$2,130,863,800	-$9,224,506	$2,125,564,893	-$14,523,414
Total direct cost	**$2,478,034,318**	**$2,469,720,028**	**-$8,314,290**	**$2,464,480,561**	**-$13,553,757**
Discounted productivity loss	$321,886,365	$320,890,805	-$995,561	$319,791,975	-$2,094,390
Total societal cost	**$2,799,920,683**	**$2,790,610,833**	**-$9,309,851**	**$2,784,272,536**	**-$15,648,147**
ICER – Payer (USD/QALY)*	–	–	**Dominant**	–	**Dominant**
ICER – Societal (USD/QALY)*	–	–	**Dominant**	–	**Dominant**

Abbreviations: AE = adverse event; GDP = gross domestic product; ICER = incremental cost-effectiveness ratio; QALY = quality-adjusted life year; USD = US dollar
*Cost-effectiveness threshold was defined as 1x GDP per capita (USD 17,860) in 2024.[42]
Costs are expressed in 2024 USD.

- From both the payer and societal perspective, the strategy is considered dominant because it improves health and lowers costs.
- In deterministic sensitivity analysis (considering a 10% variation for the lower and upper bound values of the base case), incremental cost results were most sensitive to duration of protection of the vaccine, attack rates, and vaccine effectiveness. The parameters with the highest impact on incremental QALYs were duration of protection of the vaccine, utility decrements, and duration of symptoms in outpatients (**Figure 3** and **Figure 4**).

Figure 3. Deterministic Sensitivity Analysis: Incremental Costs (Millions – USD)

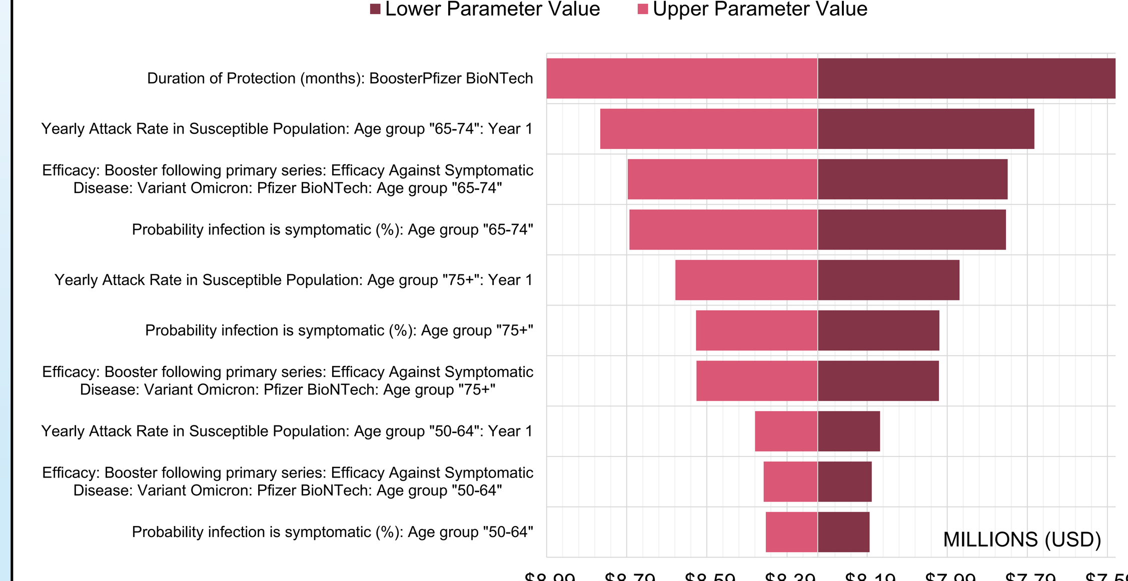
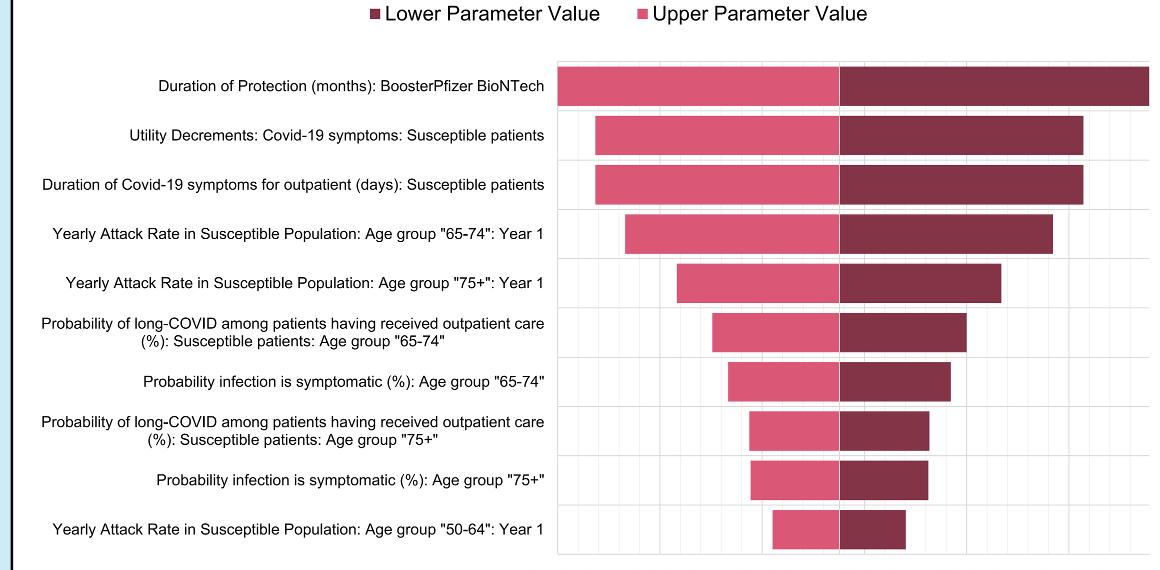


Figure 4. Deterministic Sensitivity Analysis: Incremental QALYs

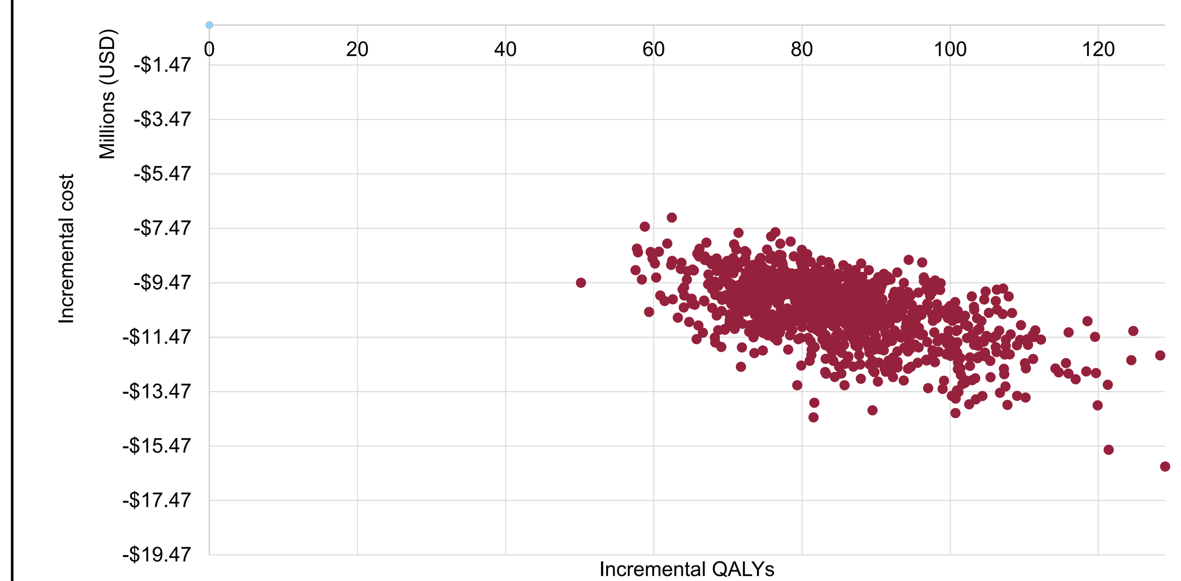


Abbreviation: QALY = quality-adjusted life year

RESULTS (cont.)

- In probabilistic sensitivity analysis, 100% of iterations using the payer perspective were dominant (**Figure 5**).

Figure 5. Probabilistic Sensitivity Analysis



Abbreviations: QALY = quality-adjusted life year

CONCLUSIONS

- **A vaccination strategy prioritizing individuals aged ≥65 years and high-risk individuals aged 18–64 years resulted in substantial public health and economic gains in Costa Rica. This strategy was dominant from both a societal perspective and a payer perspective. These benefits were further enhanced by expanding the vaccination strategy to include additional age groups, such as adults aged ≥60 years and high-risk individuals aged 18–59 years.**

References

1. WHO. WHO COVID-19 dashboard. 2024. https://data.who.int/dashboards/covid19/deaths?n=o
2. Post LA, et al. *JMIR Public Health Surveill*. 2024;10:e44398.
3. Lasalvia P, et al. *Value Health*. 2024;27(12):S238-S9.
4. South Africa NICD. Tracking SARS-CoV-2 variants. 2023. https://www.nicd.ac.za/diseases-a-z-index/disease-index-covid-19/sars-cov-2-genomic-surveillance-update/
5. Ministerio de Salud Costa Rica. Boletín epidemiológico N° 49 de 2024. https://www.ministeriodesalud.go.cr/biblioteca-de-archivos-left/documentos-ministerio-de-salud/desarrollo-humano/acuerdos-de-viajes/acuerdos-de-viajes-2024/8645-boletin-epidemiologico-n-49-2/file
6. WHO. Statement on the antigen composition of COVID-19 vaccines. 2024. https://www.who.int/news/item/26-04-2024-statement-on-the-antigen-composition-of-covid-19-vaccines
7. Pather S, et al. *Expert Rev Vaccines*. 2024;23(1):463-6.
8. Di Fusco M, et al. *J Med Econ*. 2022;25(1):605-17.
9. Cooper I, et al. *Chaos Solitons Fractals*. 2020;139:110057.
10. Amaro JE, et al. *Appl Math Model*. 2021;90:995-1008.
11. Calafiore GC, et al. *Annu Rev Control*. 2020;50:361-72.
12. Ndaïrou F, et al. *Chaos Solitons Fractals*. 2020;135:109846.
13. Huiberts AJ, et al. *Euro Surveill*. 2024;29(10):2400109.
14. Skowronski DM, et al. *Euro Surveill*. 2024;29(7):2400076.
15. Tartof SY, et al. *medRxiv*. 2023:2023.12.24.23300512.
16. Hansen CH, et al. *Lancet Infect Dis*. 2024;24(2):e73-e4.
17. van Werkhoven CH, et al. *Euro Surveill*. 2024;29(1):2300703.
18. Nguyen NN, et al. *Emerg Infect Dis*. 2022;28(11):2341-3.
19. Eythorsson E, et al. *JAMA Netw Open*. 2022;5(8):e2225320.
20. CDC. About reinfection. 2024. https://www.cdc.gov/covid/about/reinfection.html
21. Ascencio-Montiel IdJ, et al. *BMC Infect Dis*. 2022;22(1):813.
22. Angarita-Fonseca A, et al. *Front Med (Lausanne)*. 2023;10:1168628.
23. WHO. PAHO revolving fund for access to vaccines prices for the calendar year 2024. https://www.paho.org/sites/default/files/2024-11/prices-vac-2024-eng-november.pdf
24. CCSS. Modelo tarifario seguro de salud - I semestre 2024. www.ccss.sa.cr
25. INEC Costa Rica. Continuous employment survey. https://inec.cr/estadisticas-fuentes/encuestas/encuesta-continua-empleo
26. Gobierno de México. Professionals and technicians. 2004. https://www.economia.gob.mx/datamexico/es/profile/occupation/profesionistas-y-tecnicos
27. Statista. Average monthly household income in Costa Rica in 2023, by type of income. https://www.statista.com/statistics/1400634/average-monthly-household-income-by-type-costa-rica
28. CDC. Ending isolation and precautions for people with COVID-19: interim guidance. 2022. https://archive.cdc.gov/www_cdc_gov/coronavirus/2019-ncov/hcp/duration-isolation_1709314784.html
29. Di Fusco M, et al. *J Patient Rep Outcomes*. 2023;7(1):77.
30. Augustovski F, et al. *Cost Eff Resour Alloc*. 2023;21(1):21.
31. Di Fusco M, et al. *J Patient Rep Outcomes*. 2022;6(1):123.
32. Wyper G, et al. *Int J Public Health*. 2021;66:619011.
33. van Hoek AJ, et al. *PloS One*. 2011;6(3):e17030.
34. Hamel MB, et al. *Am J Med*. 2000;109(8):614-20.
35. Barbut F, et al. *Health Qual Life Outcomes*. 2019;17(1):6.
36. Instituto Nacional de Estadística y Censos Costa Rica. Estadísticas demográficas. Población por años calendario, según sexo y grupos especiales de edades 2011-2050 (Jul 2024). https://inec.cr/tematicas/listado?topics=91%252C646
37. Clark A, et al. *Lancet Glob Health*. 2020;8(8):e1003-e17.
38. Ministerio de Salud Costa Rica. Boletín epidemiológico N° 37 de 2024. https://www.ministeriodesalud.go.cr/index.php/biblioteca-de-archivos-left/documentos-ministerio-de-salud/material-informativo/material-publicado/boletines/boletines-vigilancia-vs-enfermedades-de-transmision-vectorial/boletines-epidemiologicos-2024/8090-boletin-epidemiologico-n-37-4/file
39. Ministerio de Salud Costa Rica. Base anonimizada de casos confirmados COVID 19. 2024. https://oges.ministeriodesalud.go.cr/evolucioncovid.html
40. Mustapha M, et al. *SSRN*. 2024; https://ssrn.com/abstract=5014145.
41. Sah P, et al. *Proc Natl Acad Sci U S A*. 2021;118(34):e2109229118.
42. Pichon-Riviere A, et al. *Lancet Glob Health*. 2020;8(10):e1282-e94.

Disclosures

This study was sponsored by Pfizer Inc. JJBC, CFM, MHK, IC, LB, MML, and KVH are employees of and may hold shares in Pfizer. EA and BY are employees of PPD™ Evidera™ Health Economics & Market Access, Thermo Fisher Scientific, which was contracted by Pfizer to conduct this study.

For more information please contact:
Juan José Baldi Castro
Pfizer Central America and the Caribbean
email: JuanJose.Baldi@pfizer.com
www.pfizer.com

Abstract ID: 4532. Presented at ISPOR—The Professional Society for Health Economics and Outcomes Research; 13–16 May 2025; Montreal, Quebec, Canada