EE250

Modeling the Potential Public Health Impact of Different COVID Vaccination Strategies with an Adapted Vaccine in Colombia

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INTRODUCTION

- As of September 15, 2024, SARS-CoV-2, the virus causing COVID-19, has resulted in approximately 776 million COVID-19 cases and seven million deaths worldwide, with approximately 6.4 million cases and 143,000 deaths in Colombia.[1]
- COVID-19 vaccination in Colombia significantly reduced COVID-19-related deaths, hospitalization, and intensive care unit (ICU) admissions in adults aged ≥40 years.[2] However, the protection conferred by COVID-19 vaccines has been shown to wane over time[3,4] and newer variants and sublineages of SARS-CoV-2 have emerged, with BA.2.86 and JN.1 as the latest variants in circulation as of June 2024.[5]
- Given the rapidly evolving nature of SARS-CoV-2 and the emergence of novel variants, the WHO established the Technical Advisory Group on COVID-19 Vaccine Composition (TAG-CO-VAC), which recommends new formulations of COVID-19 vaccines to mitigate the spread of novel Omicron variants.[6]

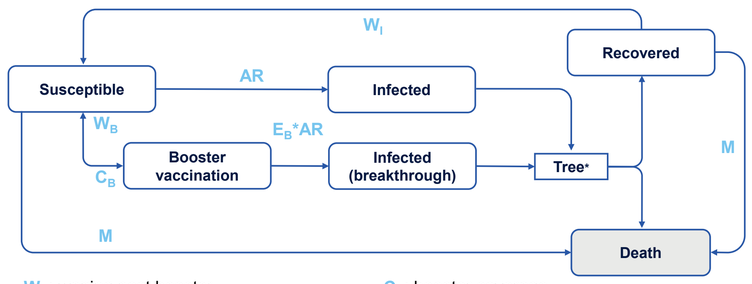
OBJECTIVE

- This study estimated the economic and public health impact of the introduction and expanded coverage of booster vaccination with a messenger RNA (mRNA), adapted vaccine in Colombia.

METHODS

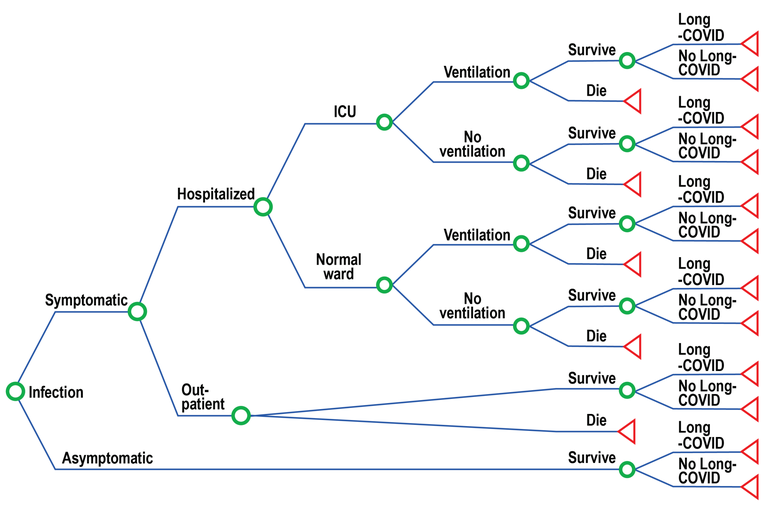
- A previously published, integrated Markov cohort decision tree model[7] was adapted to the Colombia setting to assess the impact of the introduction and expanded coverage of booster vaccination with an adapted vaccine compared with no vaccination over a 1-year time horizon.
- The model took the Colombian payer (Sistema General de Seguridad Social en Salud) and societal perspectives and used a 5% discount rate on lifetime outcomes related to premature death.
- The Markov component of the model tracked the target population through mutually exclusive health states, using a Susceptible-Infected-Recovered (SIR) structure, and the decision tree modeled disease severity and treatment pathways (e.g., outpatient, inpatient, ICU) and related outcomes (**Figure 1**).

Figure 1. Markov Structure



W_B: waning post booster
W_I: waning of infection-induced immunity
AR: attack rate
C_B: booster coverage
E_B: efficacy post booster
M: background mortality

Figure 2. Decision Tree Structure



Abbreviation: ICU = intensive care unit

Inputs

- Epidemiological model inputs were based on data from governmental sources or published in the literature (**Table 1**).
- Inpatient cost inputs were based on the literature (**Table 2**). Outpatient cost inputs were based on assumptions of one COVID-19 test, one visit to a general practitioner (GP), and use of over-the-counter pain killers for 7 days. Post-COVID-19 condition (PCC) cost inputs were based on assumptions of four COVID-19 tests, four GP visits, one specialist visit, and a 17% chance of hospitalization.[8]
- Inputs for quality-adjusted life years (QALYs) were based on the literature.[9-14]
- Inputs for initial vaccine effectiveness were 50% against symptomatic infection and 60% against hospitalization and were assumed to wane with a 6-month duration of protection, based on real-world evidence studies of vaccine effectiveness.[15-19]

METHODS (continued)

Table 1. Epidemiology and Clinical Inputs

Input description	6mo-4 years	5-11 years	12-17 years	18-29 years	30-49 years	50-64 years	65-74 years	≥75 years	References
Population size (millions)	3.3	5.5	4.8	10.4	14.6	8.0	3.2	2.0	National Administrative Department of Statistics[20]
Proportion high risk* (%)	34.3%	29.8%	21.1%	30.1%	39.4%	60.2%	78.3%	90.8%	Arciniegas et al.[21]
Annual attack rate (%)	8.9%	6.4%	6.1%	20.2%	26.6%	24.6%	26.6%	37.3%	Datos Abiertos de Colombia[22] adjusted for underreporting based on Rahmandad et al.[23]
Probability infections is symptomatic and medically attended	53.3%	53.3%	53.3%	67.9%	67.9%	67.9%	80.3%	80.3%	Sah et al.[24]
Proportion of symptomatic patients who are hospitalized (%)	7.5%	4.1%	0.9%	0.3%	0.6%	1.6%	3.5%	1.0%	Arciniegas et al.[21]
Among hospitalized patients:									
Proportion admitted to ICU (%)	9.1%	5.8%	11.8%	12.1%	13.7%	21.8%	25.1%	15.1%	Arciniegas et al.[21]
Proportion of ICU patients receiving IMV (%)	61.8%	61.8%	61.8%	61.8%	61.8%	61.8%	61.8%	61.8%	Ministry of Health and Social Protection of Colombia[25]
Probability of COVID-19 death:									
General ward (%)	0.3%	0.6%	0.0%	1.2%	1.1%	5.7%	12.0%	22.4%	Arciniegas et al.[21]
ICU without ventilation (%)	8.1%	0.0%	0.0%	9.1%	14.7%	25.4%	55.2%	52.1%	
ICU with ventilation (%)	8.1%	0.0%	0.0%	9.1%	14.7%	25.4%	55.2%	52.1%	
Outpatient care setting (%)	0.1%	0.1%	0.1%	0.0%	0.0%	0.2%	0.7%	3.7%	
Probability of PCC – Vaccinated	12.0%	12.0%	12.0%	12.3%	14.7%	14.5%	14.4%	15.5%	Angarita-Fonseca et al.[8]
Probability of PCC – Susceptible	16.0%	16.0%	16.0%	16.4%	19.6%	19.3%	19.2%	20.6%	

Abbreviations: ICU = intensive care unit; IMV = invasive mechanical ventilation; PCC = Post-COVID-19 condition
* Defined based on prevalence of obesity, hypertension, diabetes, chronic obstructive pulmonary disease, cardiovascular disease, and immunocompromised[20]

Table 2. Cost Inputs (Millions COP)

Input description	6mo-4 years	5-11 years	12-17 years	18-29 years	30-49 years	50-64 years	65-74 years	≥75 years	References
Treatment cost in normal ward – susceptible	5.3	5.3	6.8	8.6	11.8	15.0	16.5	14.2	Arciniegas et al.[21]
Treatment cost in normal ward – vaccinated	5.3	5.3	11.8	11.8	8.7	11.8	8.6	13.5	
Treatment cost in ICU – susceptible	73.1	107.6	128.9	113.6	97.2	112.9	109.7	91.5	
Treatment cost in ICU – vaccinated	73.1	107.6	128.9	38.1	114.7	106.9	123.8	114.7	

RESULTS

- A vaccination strategy targeting individuals aged ≥65 years and the high-risk population aged 18–64 years was estimated to avert 306,460 symptomatic cases, 3,381 deaths, 5,200 hospitalizations, and 39,454 lost QALYs, translating into direct and societal cost savings of 282 billion Colombian pesos (COP) and COP 518 billion, respectively.
- Expanding the vaccination strategy to target additional age groups increased public health and economic impact. For example, a strategy targeting individuals aged ≥50 years and the high-risk population aged 18–49 years increased the doses administered by 15% but also increased symptomatic cases averted by 15%, deaths averted by 5%, hospitalization averted by 16%, direct cost savings by 17%, and indirect cost savings by 21%.
- Scenario analyses showed the sensitivity of results to PCC probability and underreporting of the multiplier for attack rate.
- In sensitivity analyses, results were most sensitive to duration of protection of the vaccine, attack rates, symptomatic rates, and vaccine effectiveness.

Table 3. Base-case Analysis: Incremental Results vs. No Additional Vaccination

	≥65 Years + High-risk Population (Base case)	≥50 Years + High-risk Population	≥18 Years + High-risk Population	Total Population
Total Population	18,917,456	22,100,889	38,195,238	51,860,391
Doses administered	7,326,620	8,559,545	14,792,792	17,439,009
Health Outcomes				
Symptomatic cases avoided	306,460	352,292	575,264	600,908
COVID-19-related deaths avoided	3,381	3,564	3,690	3,721
Outpatient cases avoided	301,261	346,216	567,911	592,302
Hospitalizations avoided	5,200	6,076	7,353	8,606
Discounted QALYs gained	39,454	43,254	51,926	53,224
Economic Outcomes (billions COP)				
AE management cost	1	1	2	2
Testing cost	-7	-8	-13	-13
Inpatient treatment cost	-207	-246	-285	-306
Outpatient treatment cost	-13	-15	-24	-25
PCC treatment cost	-57	-67	-109	-114
Total direct cost	-283	-333	-428	-456
Discounted productivity loss	-236	-299	-467	-471
Total societal cost	-519	-632	-895	-927

Abbreviations: AE = adverse event; COP = Colombian peso; PCC = post-COVID-19 condition; QALY = quality-adjusted life year

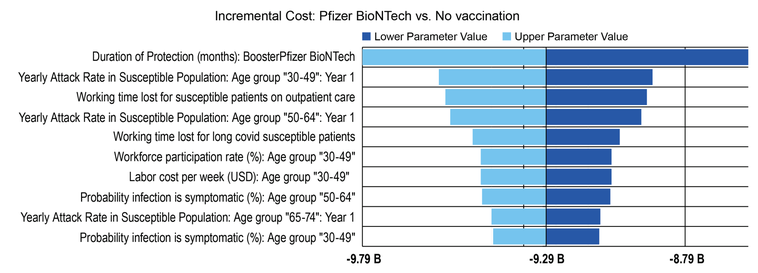
Table 4. Scenario Analysis: Incremental Results

	≥65 Years + High-risk Population (Base case)	Alternative Costs[a]	Alternative Costs[b]	PCC Excluded	AR Multiplier (X5)	AR Multiplier (X5) + No PCC	AR Multiplier (X2) + No PCC	AR Multiplier (X1) + No PCC
Health Outcomes								
Symptomatic cases avoided	306,460	306,460	306,460	306,460	151,733	151,733	60,364	30,129
COVID-19-related deaths avoided	3,381	3,381	3,381	3,381	1,666	1,666	661	330
Outpatient cases avoided	301,261	301,261	301,261	301,261	149,177	149,177	59,351	29,624
Hospitalizations avoided	5,200	5,200	5,200	5,200	2,556	2,556	1,013	505
Discounted QALYs gained	39,454	39,454	39,454	34,247	19,416	16,861	6,688	3,335
Economic Outcomes (billions COP)								
AE management cost	1	1	1	1	1	1	1	1
Testing cost	-7	-7	-7	-7	-3	-3	-1	-1
Inpatient treatment cost	-207	-509	-59	-207	-102	-102	-40	-20
Outpatient treatment cost	-13	-13	-13	-13	-6	-6	-2	-1
PCC treatment cost	-57	-57	-57	0	-28	0	0	0
Total direct cost	-283	-585	-134	-225	-139	-110	-43	-21
Discounted productivity loss	-236	-236	-236	-139	-16	-69	-27	-14
Total societal cost	-519	-821	-370	-364	-255	-179	-70	-35

Abbreviations: AE = adverse event; AR = attack rate; COP = Colombian peso; PCC = post-COVID-19 condition; QALY = quality-adjusted life year.
[a] based on Fernandez-Trujillo et al.[26]
[b] based on Alvis-Zakzuk et al.[27]

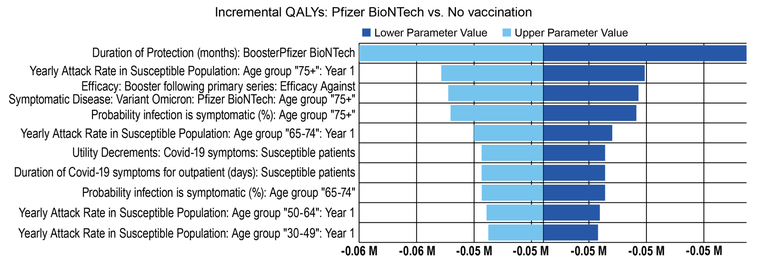
RESULTS (continued)

Figure 3. Deterministic Sensitivity Analysis: Incremental Costs



Abbreviation: B = billion

Figure 4. Deterministic Sensitivity Analysis: Incremental QALYs



Abbreviation: QALY = quality-adjusted life year, M = million

CONCLUSIONS

A vaccination strategy against COVID-19 with an adapted vaccine compared with no vaccination targeting individuals aged ≥65 years and those aged 18–64 years at high risk yields substantial public health and economic gains annually in Colombia, but expansion to additional age groups provides additional gains.

References

1. World health Organization. WHO COVID-19 dashboard. Accessed July 5, 2024, https://data.who.int/dashboards/covid19/deaths?n=o
2. Paternina-Caicedo A, Jit M, Alvis-Guzman N, et al. Effectiveness of CoronaVac and BNT162b2 COVID-19 mass vaccination in Colombia: A population-based cohort study. *The Lancet Regional Health–Americas*. 2022;12
3. Lau JJ, Cheng SMS, Leung K, et al. Real-world COVID-19 vaccine effectiveness against the Omicron BA.2 variant in a SARS-CoV-2 infection-naive population. *Nature Medicine*. 2023/02/01 2023;29(2):348-357. doi:10.1038/s41591-023-02219-5
4. Rosenblum HG, Wallace M, Godfrey M, et al. Interim recommendations from the Advisory Committee on Immunization Practices for the use of bivalent booster doses of COVID-19 vaccines—United States, October 2022. *Morbidity and Mortality Weekly Report*. 2022;71(45):1436-1441.
5. National Institute for Communicable Diseases. Tracking SARS-CoV-2 Variants. Updated December 14, 2023. Accessed December 20, 2023, https://www.nicd.ac.za/diseases-a-z-index/disease-index-covid-19/sars-cov-2-genomic-surveillance-update/
6. World Health Organization. Statement on the antigen composition of COVID-19 vaccines. Updated April 26, 2024. Accessed July 5, 2024, 2024. https://www.who.int/news/item/26-04-2024-statement-on-the-antigen-composition-of-covid-19-vaccines
7. Di Fusco M, Marczell K, Deger KA, et al. Public health impact of the Pfizer-BioNTech COVID-19 vaccine (BNT162b2) in the first year of rollout in the United States. *Journal of Medical Economics*. 2022;25(1):605-617.
8. Angarita-Fonseca A, Torres-Castro R, Benavides-Cordoba V, et al. Exploring long COVID condition in Latin America: Its impact on patients' activities and associated healthcare use. *Frontiers in Medicine*. 2023;10:1168628.
9. Augustovski F, Bardach A, Santoro A, et al. Cost-effectiveness of COVID-19 vaccination in Latin America and the Caribbean: an analysis in Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, and Peru. *Cost Effectiveness and Resource Allocation*. 2023;21(1):21.
10. Di Fusco M, Sun X, Moran MM, et al. Impact of COVID-19 and effects of BNT162b2 on patient-reported outcomes: quality of life, symptoms, and work productivity among US adult outpatients. *J Patient Rep Outcomes*. Dec 5 2022;6(1):123. doi:10.1186/s41687-022-00528-w
11. Barbut F, Galperine T, Vanhems P, et al. Quality of life and utility decrement associated with *Clostridium difficile* infection in a French hospital setting. *Health Qual Life Outcomes*. Jan 11 2019;17(1):6. doi:10.1186/s12955-019-1081-5
12. Hamel MB, Phillips RS, Davis RB, et al. Outcomes and cost-effectiveness of ventilator support and aggressive care for patients with acute respiratory failure due to pneumonia or acute respiratory distress syndrome. *Am J Med*. Dec 1 2000;109(8):614-20. doi:10.1016/s0002-9343(00)00591-x
13. Wyper G, Assunção R, Colzani E, et al. Burden of disease methods: a guide to calculate COVID-19 disability-adjusted life years. *International journal of public health*. 2021;66:619011.
14. Van Hoek AJ, Underwood A, Jit M, Miller E, Edmunds WJ. The impact of pandemic influenza H1N1 on health-related quality of life: a prospective population-based study. *PloS one*. 2011;6(3):e17030.
15. Link-Gelles R. Early estimates of updated 2023–2024 (monovalent XBB. 1.5) COVID-19 vaccine effectiveness against symptomatic SARS-CoV-2 infection attributable to co-circulating Omicron variants among immunocompetent adults—Increasing Community Access to Testing Program, United States, September 2023–January 2024. *MMWR Morbidity and Mortality Weekly Report*. 2024;73
16. Tartof SY, Slezak JM, Frankland TB, et al. Estimated Effectiveness of the BNT162b2 XBB Vaccine Against COVID-19. *JAMA Internal Medicine*. 2024:2023.12.24.23300512. doi:10.001/jamainternmed.2024.1640
17. Nguyen NN, Houhamdi L, Delorme L, Colson P, Gautret P. Reinfections with Different SARS-CoV-2 Omicron Subvariants, France. *Emerg Infect Dis*. Nov 2022;28(11):2341-2343. doi:10.3201/eid2811.221109
18. Eythorsson E, Runolfsdottir HL, Ingvarsson RF, Sigurdsson MI, Palsson R. Rate of SARS-CoV-2 reinfection during an omicron wave in Iceland. *JAMA Netw Open*. Aug 1 2022;5(8):e2225320. doi:10.1001/jamanetworkopen.2022.25320
19. Centers for Disease Control and Prevention (CDC). Reinfections and COVID-19. Accessed October 30, 2022. https://www.cdc.gov/coronavirus/2019-ncov/your-health/reinfection.html
20. National Administrative Department of Statistics. Serie nacional de población por área, sexo y edad para el periodo 2020-2070. Accessed May 3, 2024, 2024. https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-poblacion
21. Arciniegas J, Bolaños-López J, Reyes SJ, et al. EPH159 Burden of COVID-19 and Its Associated Clinical Characteristics in Colombia: A Retrospective Database Analysis. *Value in Health*. 2024;27(6):S181.
22. Datos Abiertos de Colombia. Casos Positivos de COVID-19 En Colombia. Accessed June 4, 2024, 2024. www.datos.gov.co/Salud-y-Protecci-n-Social/Casos-positivos-de-COVID-19-en-Colombia-/gt2j-8ykr/data
23. Rahmandad H, Lim TY, Sterman J. Behavioral dynamics of COVID-19: estimating underreporting, multiple waves, and adherence fatigue across 92 nations. *System Dynamics Review*. 2021;37(1):5-31.
24. Sah P, Fitzpatrick MC, Zimmer CF, et al. Asymptomatic SARS-CoV-2 infection: A systematic review and meta-analysis. *Proceedings of the National Academy of Sciences*. 2021;118(34):e2109229118.
25. Ministry of Health and Social Protection of Colombia. COVID-19 Tracking. Accessed May 3, 2024, https://www.sispro.gov.co/central-prestadores-de-servicios/Pages/SEGUIMIENTOCOVID19.aspx
26. Fernandez-Trujillo L, Sangiovanni S, Castrillon AI, et al. Unveiling the truth: is COVID-19 reimbursement in Colombia a flawed design? A cost-of-illness analysis for moderate, severe and critical infections. *BMJ Open Respir Res*. Apr 5 2024;11(1)doi:10.1136/bmjresp-2023-002097
27. Alvis-Zakzuk NJ, Flórez-Tanus Á, Díaz-Jiménez D, et al. How Expensive Are Hospitalizations by COVID-19? Evidence From Colombia. *Value Health Reg Issues*. Sep 2022;31:127-133. doi:10.1016/j.vhri.2022.04.005.

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