EE474

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

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INTRODUCTION

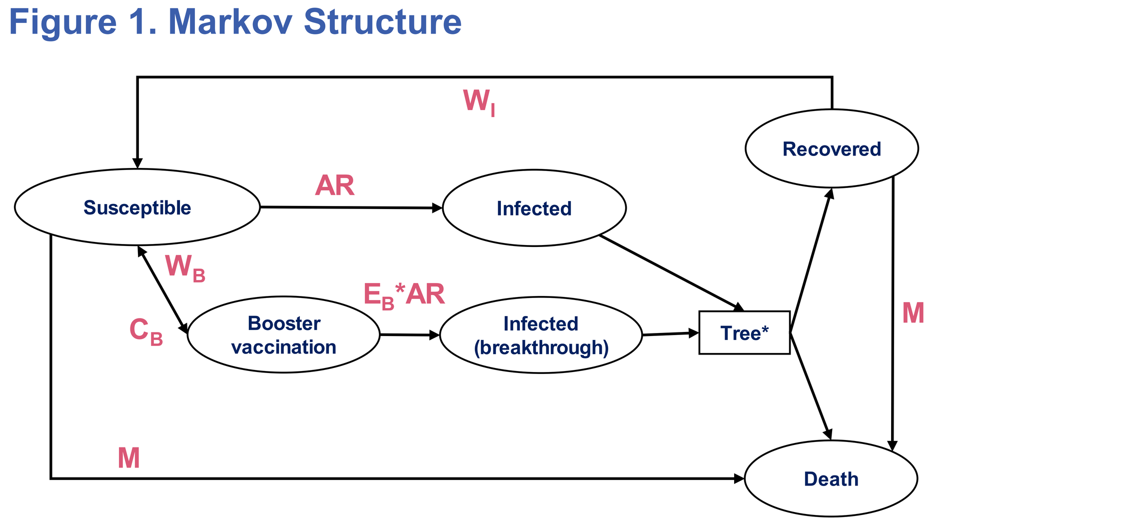
- The worldwide impact of COVID-19, caused by the SARS-CoV-2 virus, includes approximately 777 million cases and 7 million deaths as of December 21, 2024. About 1.3 million cases and 20,200 deaths have occurred in Guatemala.[1]
- Although COVID-19 has become endemic, it still continues to circulate in Latin America and the Caribbean[2] and imposes considerable economic costs on the national healthcare system in Guatemala.[3]
- By the end of December 2023, Guatemala had administered over 20.38 million doses of COVID-19 vaccine, with 40% of the population receiving a complete primary series and 21% receiving at least one booster dose.[1] Although COVID-19 vaccines initially provide protection, their efficacy wanes over time,[4,5] and new 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.[6]
- In response to the rapidly evolving nature of SARS-CoV-2 and the emergence of novel variants, the WHO created the Technical Advisory Group on COVID-19 Vaccine Composition.[6] This group suggests new COVID-19 vaccine formulations to address the spread of novel variants.[6] In Guatemala, the BNT162b2 COVID-19 JN.1 vaccine is anticipated to receive approval in 2025.
- This modeling study evaluated the economic and health outcomes of vaccination with an annual adapted[a] COVID-19-booster vaccine[7] from both a public payer and societal perspective in Guatemala.

[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 integrated Markov cohort decision tree model[8] was adapted for the Guatemala setting to estimate the impact of vaccine strategies 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=1,240,482) as part of the base case.
- Using a Susceptible-Infected-Recovered structure, the Markov component of the model tracked the target population through mutually exclusive health states.[9-12] The decision tree modeled disease severity, treatment pathways (e.g., outpatient, inpatient, ICU), and related outcomes (**Figure 1** and **Figure 2**).

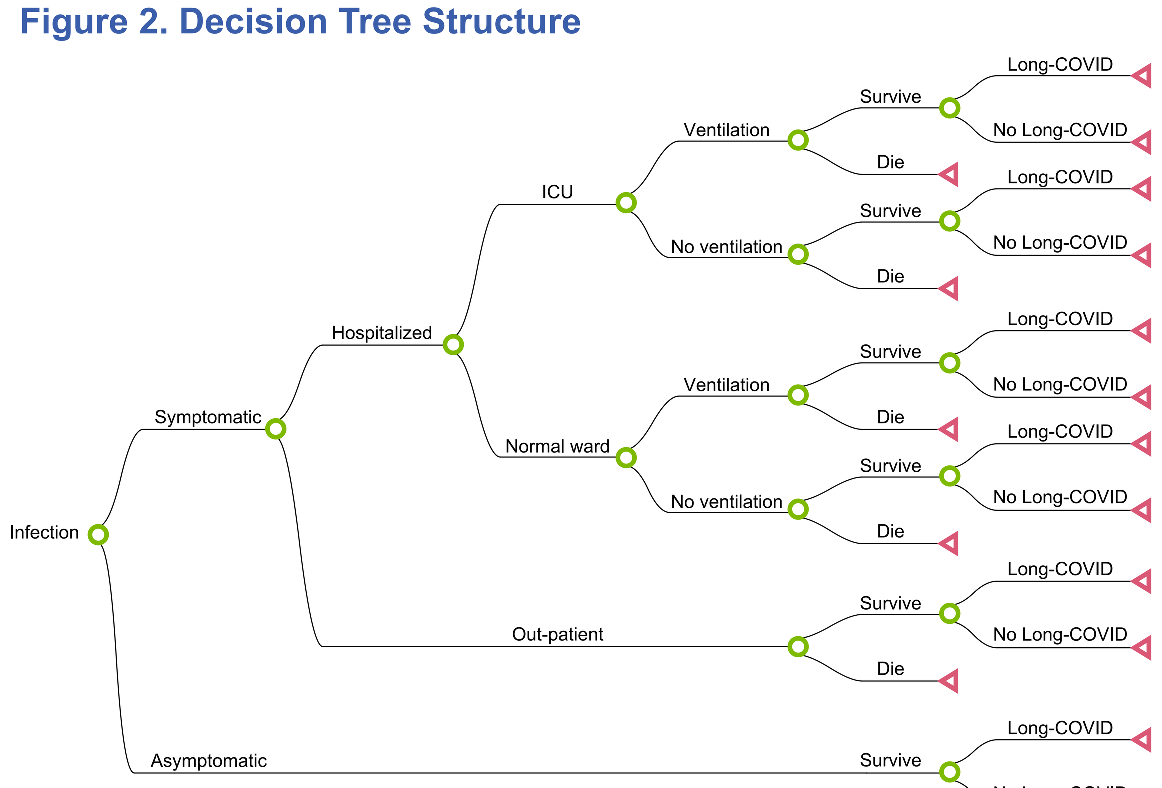
Figure 1. Markov Structure



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 derived from government data, published literature, or assumptions based on data from other countries when local data were unavailable (**Table 1**).
- Complications for the high-risk population were modeled using risk ratios for hospitalization, severe COVID-19 requiring ICU care, and mortality.[13]
- Inpatient and outpatient treatment cost inputs and length of stay for inpatient treatment were sourced from a local study.[3]
- Long COVID cost inputs assumed four COVID-19 tests, four general practitioner visits, one specialist visit, and a 17% chance of hospitalization.[14] Vaccine acquisition costs per dose were obtained from the Pan American Health Organization´s revolving fund.[15]
- The indirect costs of productivity losses due to COVID-19 and long COVID were estimated from a societal perspective, considering workforce participation rates, weekly labor costs, and working time lost. Because of data limitations, Guatemala's workforce participation rate was derived from the 2023 population distribution[16] and 2019 occupied population distribution.[17] Weekly labor costs were based on the 2022 average salary from the National Institute of Statistics of Guatemala[18,19] and salary increases for experience from Mexico.[20]
- Utility inputs were sourced from the literature.[21-26]
- Informed by real-world evidence, the model assumed a vaccine profile with 50% effectiveness against infections, 60% against symptomatic infections, and 70% against hospitalization, and a duration of protection of 6 months.[27-34]
- This study used a 3% discount rate for costs and health effects.[21]
- 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)	4,056.1	4,524.4	1,645.6	604.4	429.3	National Institute of Statistics of Guatemala[18]
Proportion high risk	1.1%	4.1%	10.0%	16.0%	21.0%	Clark et al.[35]
Annual attack rate	20.0%	29.1%	33.4%	35.7%	30.6%	Government of Guatemala, Ministry of Public Health Social Assistance[36] (adjusted for underreporting 146.3 from Mustapha et al. using Colombia as proxy[37])
Probability that infection is symptomatic	67.90%	67.90%	67.90%	80.30%	80.30%	Sah et al.[38]
Proportion of symptomatic patients (medically attended) who are hospitalized	0.08%	0.14%	0.38%	0.68%	1.21%	Ministry of health Costa Rica[39,40] (due to lack of data)
Proportion of hospitalized patients admitted to ICU	0.17%	0.20%	0.28%	0.42%	0.42%	Ministry of health of Costa Rica[39,40] Ascencio-Montiel et al.[13]
Proportion of ICU patients on mechanical ventilation	71%	71%	71%	71%	71%	Augustovski et al.[21]
Probability of death among hospitalized patients on normal ward without ventilation	0.16 %	1.26%	2.70%	2.20%	3.87%	Ministry of health Costa Rica[39,40] (due to lack of data)
Probability of long COVID – *Vaccinated*	12.31%	14.56%	14.64%	13.89%	15.47%	Angarita-Fonseca et al.[14]
Probability of long COVID – *Susceptible*	16.41%	19.42%	19.52%	18.51%	20.63%	

Abbreviation: ICU = intensive care unit

RESULTS

- Compared with no vaccination, the vaccination strategy targeting individuals aged ≥65 years and high-risk individuals aged 18–64 years was projected to prevent 10,943 symptomatic cases, 10,843 outpatient cases, 101 hospitalizations, 298 lost QALYs, and three deaths, yielding an incremental direct cost reduction of USD 7,943,644 and total societal cost savings of USD 8,807,605 (**Table 2**).
- Compared with no vaccination, the alternative vaccination strategy (targeting individuals aged ≥60 years and high-risk populations aged 18–59 years) was projected to avert 13,670 symptomatic cases, 13,557 outpatient cases, 113 hospitalizations, 375 lost QALYs, and three deaths. This approach led to an incremental direct cost reduction of USD 9,850,390 and total societal cost savings of USD 11,150,313 (**Table 2**).
- From the perspectives of both the payer and society, the strategy is deemed dominant because of its improved health benefits and lower costs.
- Deterministic sensitivity analysis (with an 10% variation for the lower and upper bound values of the base case) showed that incremental costs results were most influenced by the duration of vaccine protection, outpatient visit costs, and attack rates (**Figure 5**), and incremental QALYs results were most influenced by the duration of vaccine protection, utility decrements, and duration of symptoms (**Figure 4**).
- Probabilistic sensitivity analysis showed that all iterations were dominant (**Figure 5**).

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	11,259,785	11,259,785	0	11,259,785	0
Doses administered	0	154,759	154,759	198,783	198,783
Health outcomes					
Symptomatic cases	2,274,089	2,263,146	-10,943	2,260,419	-13,670
COVID-19-related deaths	142	139	-3	138	-3
Outpatient cases	2,267,996	2,257,154	-10,843	2,254,439	-13,557
Hospitalizations	6,093	5,993	-101	5,981	-113
Discounted QALYs lost	52,472	52,174	-298	52,097	-375
Economic outcomes					
Vaccine acquisition	–	$2,785,667	$2,785,667	$3,578,095	$3,578,095
Vaccine administration	–	$651,536	$651,536	$836,877	$836,877
AE management cost	–	$59,131	$59,131	$75,951	$75,951
Long COVID treatment costs	$1,045,140,682	$1,040,294,032	-$4,846,651	$1,038,892,302	-$6,248,380
Inpatient treatment cost	$57,534,238	$56,478,961	-$1,055,277	$56,365,973	-$1,168,266
Outpatient treatment cost	$1,158,424,405	$1,152,886,355	-$5,538,050	$1,151,499,737	-$6,924,667
Total direct costs	**$2,261,099,325**	**$2,253,155,681**	**-$7,943,644**	**$2,251,248,935**	**-$9,850,390**
Discounted productivity loss	$338,658,549	$337,794,588	-$863,961	$337,358,627	-$1,299,923
Total societal cost	**$2,599,757,875**	**$2,590,950,269**	**-$8,807,605**	**$2,588,607,562**	**-$11,150,313**
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 6,300) in 2024.[41]
Costs are expressed in 2024 US dollars

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

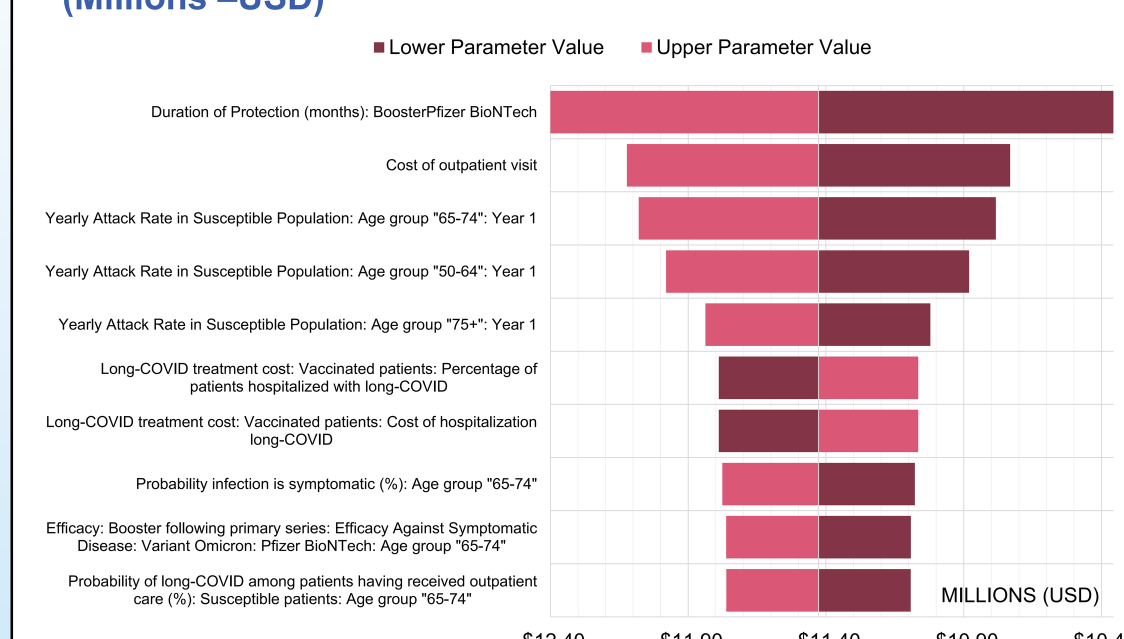
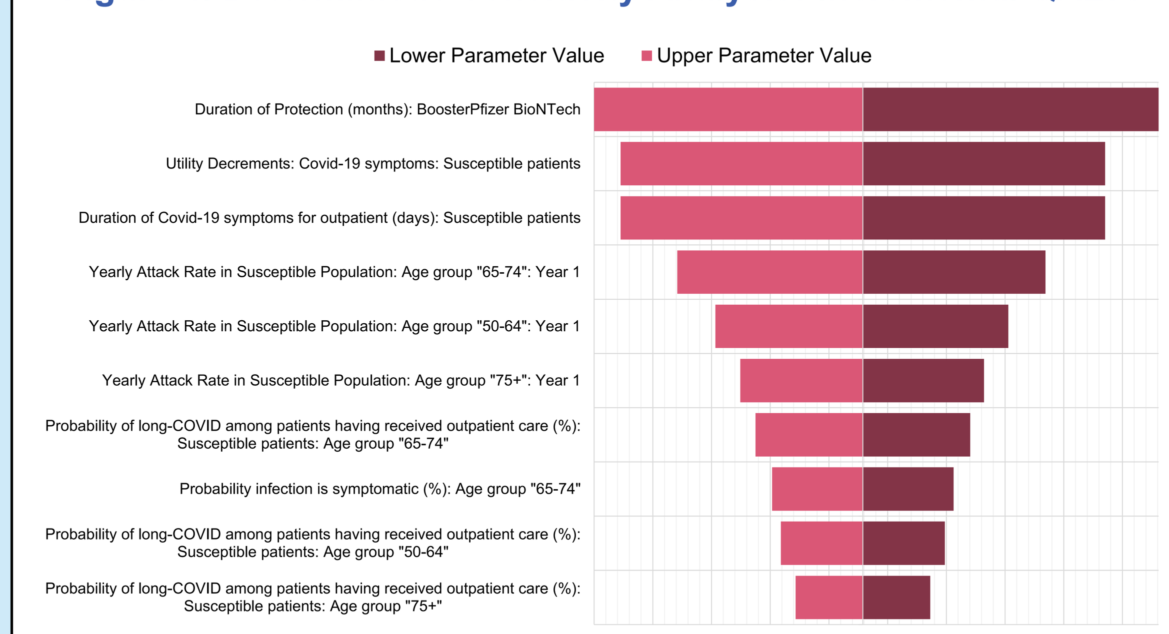
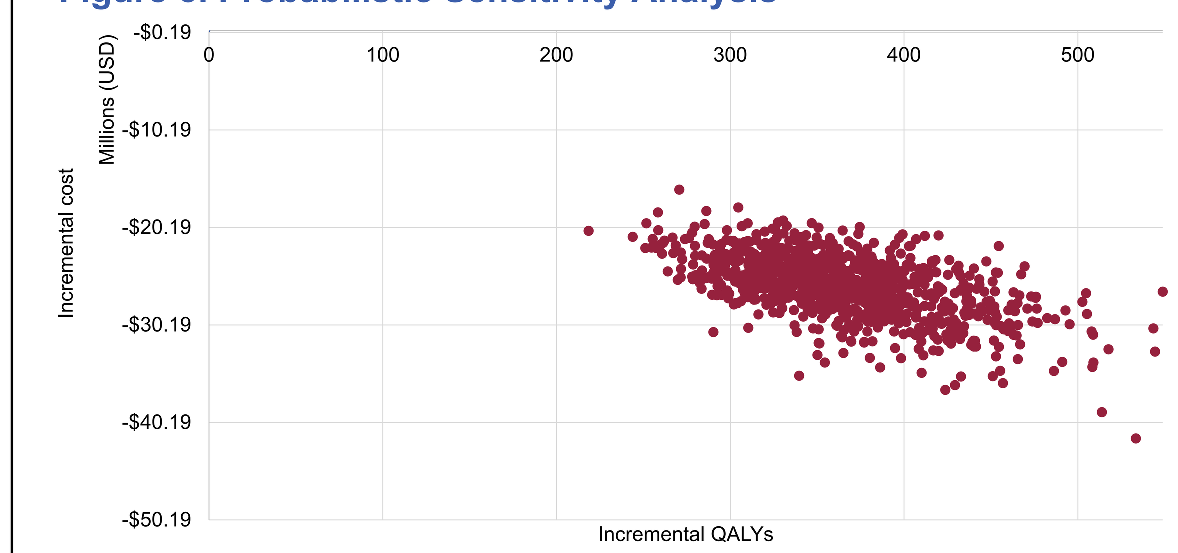


Figure 4. Deterministic Sensitivity Analysis: Incremental QALYs



Abbreviation: QALY = quality-adjusted life year

Figure 5. Probabilistic Sensitivity Analysis



Abbreviations: QALY = quality-adjusted life year

CONCLUSIONS

- **A vaccination strategy targeting individuals aged ≥65 years and high-risk individuals aged 18–64 years resulted in significant annual public health and economic gains. Compared with no vaccination, an annual booster dose of BNT162b2 was dominant from both a societal and a payer perspective. Expanding vaccination strategies to encompass a wider age range may be a vital public health approach, offering dominant advantages from a societal viewpoint or cost-effectiveness from a payer perspective. These benefits were further amplified by including additional age groups, such as adults aged ≥60 years and high-risk individuals aged 18–59 years.**

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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.

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