Poster HSD27

Constrained Optimization Model to Estimate Best Booster Allocation Strategy to Minimize Hospital Bed Days Under a Fixed Healthcare Budget

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Introduction

- Vaccine boosters are currently used to maintain protection against disease due to the SARS-CoV-2 virus (the virus that causes COVID-19), with continued reductions in severe and life-threatening infections.[1]
- Ongoing booster campaigns are an additional cost burden to already limited healthcare budgets in many countries, such as Brazil.[2]
- Given the limited budgets and the need to maximize healthcare gains, public health policymakers face difficult choices over which boosters to use and who should receive them.

Objective

- Identify the best booster allocation strategy (BAS) that maximizes healthcare outcomes within a limited budget applying a constrained optimization (CO) model from a healthcare perspective using Brazil as a base-case country.

Plain Language Summary

With a need to increase nationwide health benefits despite reduced budgets, decision makers have a difficult choice over which COVID-19 booster brand to recommend. Using Brazil as an example, we identified the best booster strategy for improving health within a small national budget. A model was created to identify the best booster strategy that would reduce the time patients spent in hospital beds at a target expense of USD 2.10/person. Three booster options, Booster 1 (B_1 [USD 1]), Booster 2 (B_2 [USD 2]) and no booster (NB [USD 0]), were considered: B_1 and B_2 were 55% and 75% successful against mild/moderate COVID-19, respectively. Both boosters were considered to have 90% effectiveness against severe and critical COVID-19.

A mixed-booster approach increased the health benefits of patients within the maximum budget. Lower-cost COVID-19 vaccines with slightly reduced effectiveness against mild or moderate disease may be more suitable for younger people. Higher-cost COVID-19 vaccines with slightly greater effectiveness against mild or moderate disease may be more suitable for older people. Boosters reduced total costs by 61% and medical resource costs by 81%, compared with NB. Based on disease risk and age, costs were reduced by 57% to 66%.

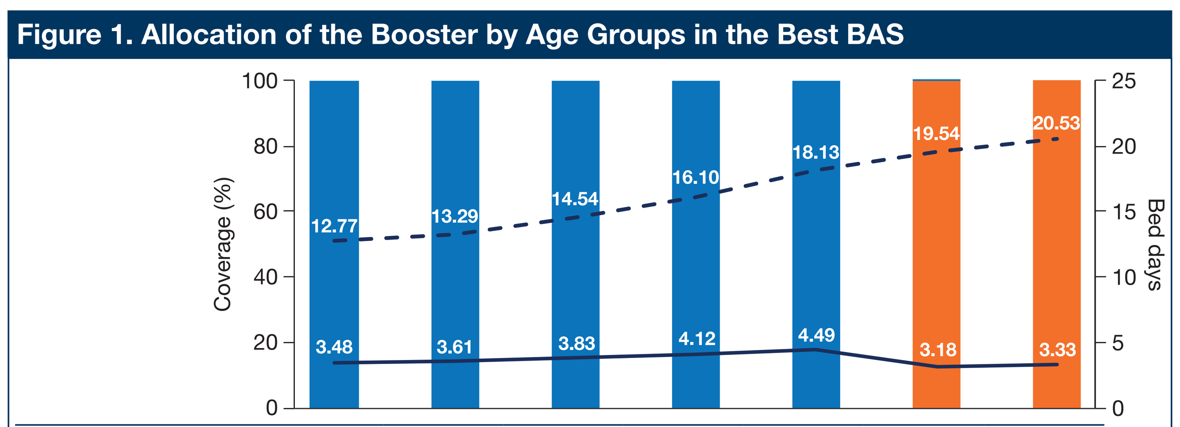
Our model selects the best booster strategy to reduce time spent in hospital beds across different ages, and without going over budget. Decision makers could use this model to achieve the best health benefits within the confines of a reduced budget.

Results and Interpretation

Booster Strategies Allocation

- The details of total bed days needed for the best BAS versus NB are shown by age groups in **Figure 1**.
  - The best BAS identified was B_2 for all adults aged ≥70 years and B_1 for adults <70 years.
  - NB was not recommended for any age group.

Figure 1. Allocation of the Booster by Age Groups in the Best BAS



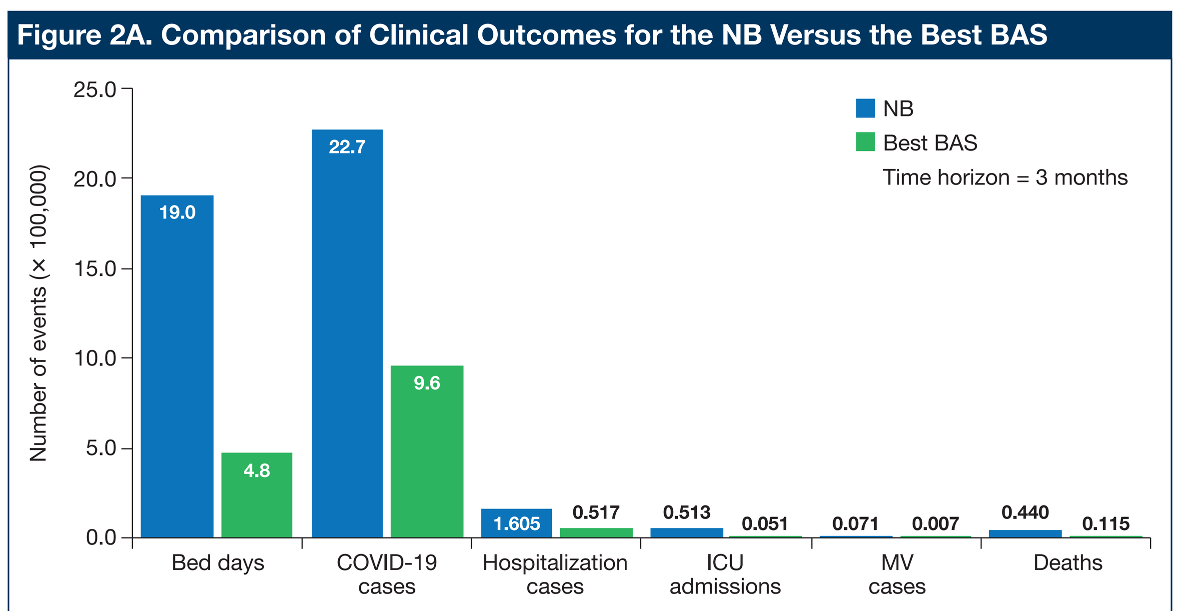
Yrs	18–29	30–39	40–49	50–59	60–69	70–79	≥80
NB, coverage (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B_1, coverage (%)	100.00	100.00	100.00	100.00	100.00	0.23	0.00
B_2, coverage (%)	0.00	0.00	0.00	0.00	0.00	99.77	100.00
Bed days per 1,000 individuals – with booster	3.48	3.61	3.83	4.12	4.49	3.18	3.33
Bed days per 1,000 individuals – without booster	12.77	13.29	14.54	16.10	18.13	19.54	20.53
Total bed days – with booster	99,126	99,164	90,053	83,906	64,042	25,903	13,375
Total bed days – without booster	363,624	365,464	341,759	328,252	258,796	159,264	82,512

B_1, booster 1; B_2, booster 2; yr, year.

Clinical and Cost Outcomes Associated With the Optimal Allocation Strategy

- The best BAS reduced bed days by 75% versus an NB strategy among all age groups, corresponding to 1.42 million bed days avoided (**Figure 2A**).
  - Hospitalizations were reduced by 68%, corresponding to 109,000 hospitalizations avoided.
  - Intensive care unit (ICU) admissions and mechanical ventilation (MV) episodes were both reduced by 90%, corresponding to 46,000 ICU admissions and 6,000 MV episodes avoided.
  - Deaths among patients were reduced by 74%, corresponding to 33,000 deaths avoided.

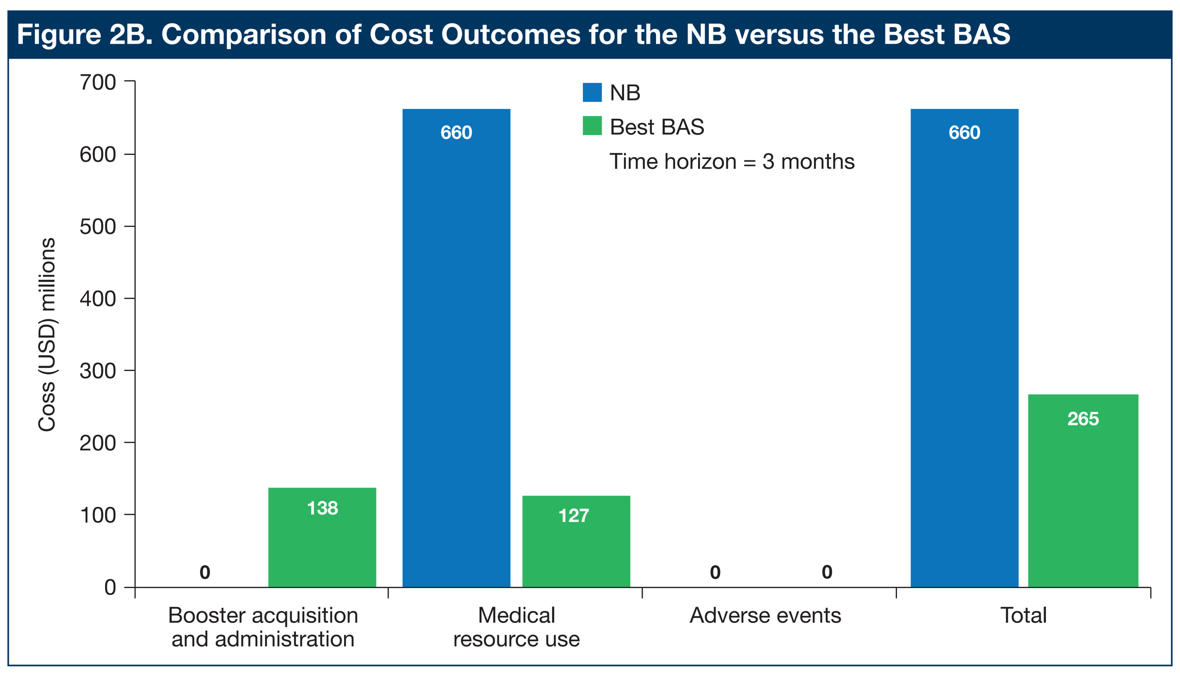
Figure 2A. Comparison of Clinical Outcomes for the NB Versus the Best BAS



BAS, booster allocation strategy; ICU, intensive care unit; MV, mechanical ventilation; NB, no booster.

- The best BAS resulted in a reduction of USD 395 million over a 3-month period to the public health budget compared to a NB strategy (**Figure 2B**) and provided:
  - An additional USD 138 million for booster acquisition and administration in the best BAS.
  - A reduction of USD 533 million in COVID-related medical resources.

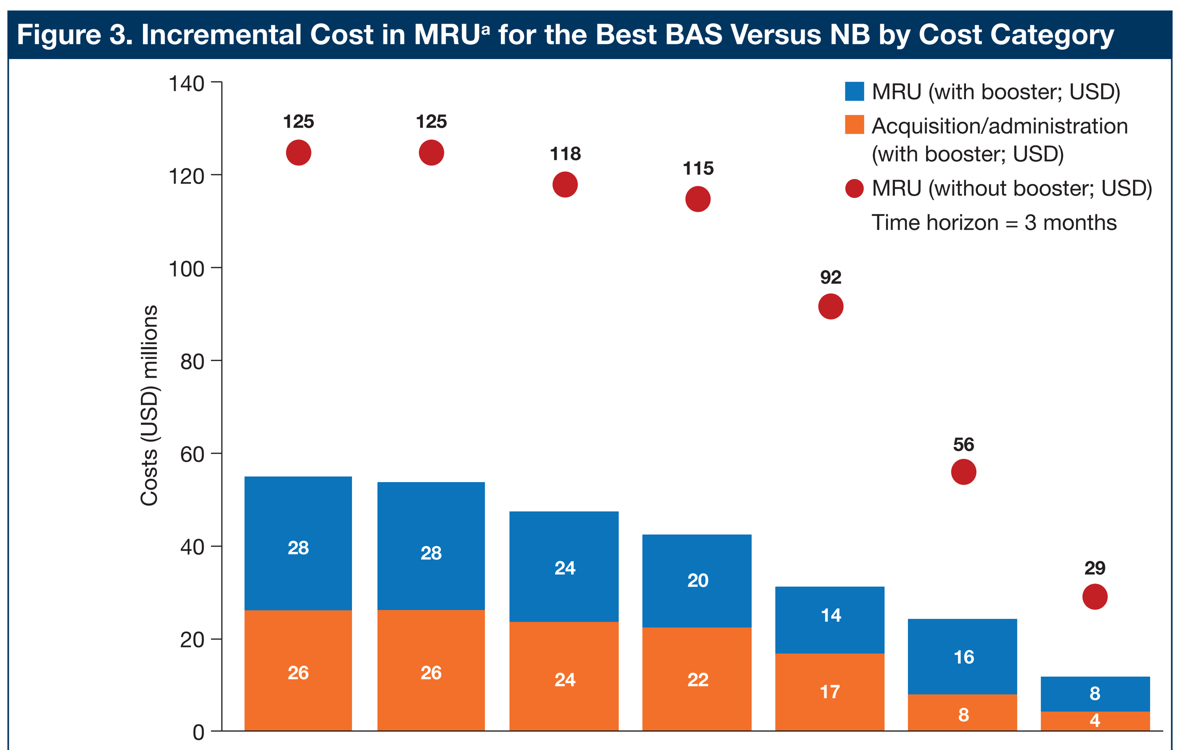
Figure 2B. Comparison of Cost Outcomes for the NB versus the Best BAS



BAS, booster allocation strategy; NB, no booster.

- The incremental medical resource use (MRU) cost for the best BAS compared with NB by cost categories is presented by age groups in **Figure 3**.

Figure 3. Incremental Cost in MRU[a] for the Best BAS Versus NB by Cost Category



Yrs	18–29	30–39	40–49	50–59	60–69	70–79	≥80
Acquisition/ administration (with booster; USD)	28,478,066	27,504,686	23,507,406	20,386,126	14,277,518	16,285,454	8,037,083
MRU (with booster; USD)	26,236,293	26,089,008	23,756,087	22,185,769	16,974,855	7,634,420	3,928,140
MRU (without booster; USD)	124,700,874	125,186,179	118,400,312	114,981,604	91,675,780	56,346,874	29,151,030
Booster cost per person (USD)	1.00	1.00	1.00	1.00	1.00	2.00	2.00
MRU costs saved (USD)	98,464,581	99,097,171	94,644,225	92,795,835	74,700,925	48,712,454	25,222,890
Total costs saved (USD)	69,986,515	71,592,485	71,136,818	72,409,709	60,423,407	32,427,000	17,185,807

[a]Includes COVID-related costs.
BAS, booster allocation strategy; MRU, medical resource use; NB, no booster; yr, years.

- Comparing best BAS versus each of B_1, B_2, or NB for all individuals is presented in **Table 1**. The NB strategy for all individuals is the least desirable option, with the highest costs and the least benefits.
- For all patients, the best BAS:
  - Compared with B_1 saved 20,065 additional bed days at an extra cost of USD 8 million, which is within the budgetary constraint.
  - Compared with B_2 for all individuals resulted in an additional 154,602 bed days at a net extra cost of USD 81 million, which would be unaffordable.

Table 1. Estimated Total Costs and Health Outcomes for Each Strategy in Brazil

Booster option	Total Costs (USD)[a]	Symptomatic Cases, n	Deaths, n	Mild Cases, n	Hospital Admissions, n	Bed Days, n
B_1	257,701,456	1,010,594	12,632	951,009	54,257	495,633
B_2	346,128,426	555,827	12,632	528,338	32,423	320,967
NB	660,675,791	2,273,836	37,897	2,113,353	160,484	1,899,673
Best BAS	265,280,913	962,929	11,470	911,180	51,749	475,569

[a]Includes booster acquisition, administration and MRU.
BAS, booster allocation strategy; B_1, booster 1; B_2, booster 2; NB, no booster.

Limitations

- Only budget constraint is considered, although willingness to be vaccinated, booster availability and administration limitations could also be included.
- The assumption that booster effectiveness is not dependent on the primary vaccine was made due to lack of available data.[3]
- The model assumes a constant booster effectiveness over 3 months.[3] However, in real life, effectiveness may wane over time and can vary between individuals and by the booster used.
- The attack rate associated with COVID-19 infection among vaccinated adults, 6 months after the primary vaccine, is a key driver of these results.
- The impact of boosters on herd immunity is not included in the model, suggesting this analysis may be conservative if boosters do reduce transmission.[4]
- Asymptomatic infections and the long-term impact of COVID-19 were not considered. Boosters were assumed to not cause any severe (grade ≥3) adverse events.

Conclusions

- Using Brazil as a hypothetical base-case country, a mixed-booster strategy by age group provided improved health gains at the predefined budget instead of selecting a single-booster or a non-booster approach for the eligible population, where the booster options differed only in cost, and in effectiveness of protection against mild and moderate disease.
- This hypothetical analysis demonstrated that:
  - A non-booster approach is ineffective at reducing bed days due to COVID-19.
  - Lower-cost COVID-19 vaccines with slightly reduced effectiveness against mild or moderate disease may be more suitable for younger populations.
  - Higher-cost COVID-19 vaccines with slightly greater effectiveness against mild or moderate disease may be more suitable for older populations.
- This CO model provides public health policymakers with a tool able to allocate available boosters to optimize healthcare outcomes, following COVID-19 infection, within a limited healthcare budget.
- The CO model can be adapted to different countries and settings by updating the locally relevant inputs for population age-structure and prevalence of comorbidities, COVID-19 incidence and case distribution, booster costs and effectiveness, MRU costs, and local budget constraints.

Methods

Booster Vaccine Options

- 3 booster options were considered for the analysis: 2 were hypothetical booster (B_1 and B_2) strategies assumed to have similar effectiveness against severe and critical COVID-19 infections (90%) and different effectiveness against mild and moderate infections (55% and 75%, respectively).
  - B_1 had a cost per dose of USD 1 and B_2 a cost per dose of USD 2 (costs includes acquisition, storage requirements, administration and associated risks).
  - The NB strategy had no effectiveness or additional unit cost to the COVID-related costs.

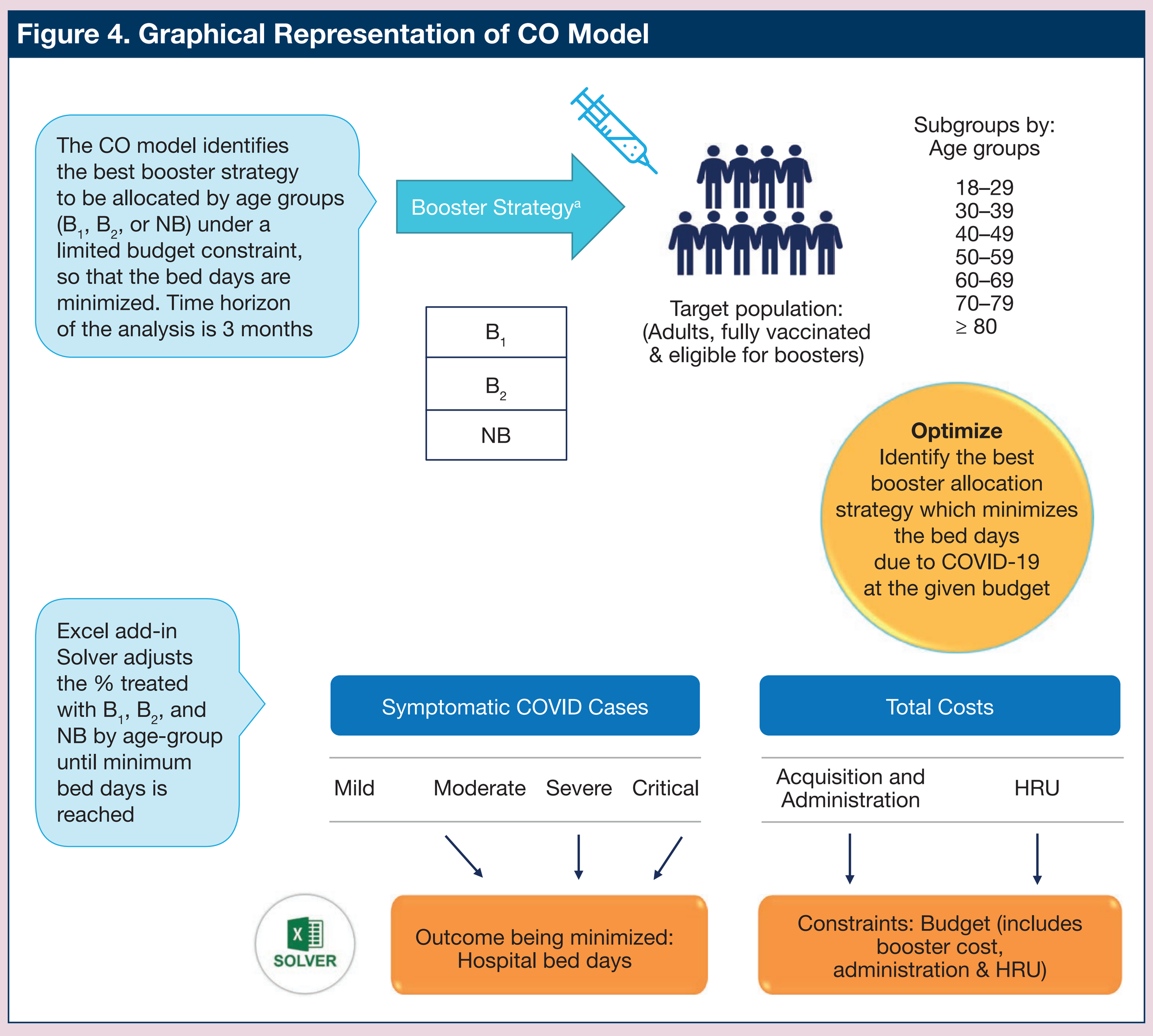
Key Outcome

- Reduction of hospital bed days due to COVID-19 was selected as the healthcare outcome to minimize, as this is a key objective for healthcare providers.[5]

CO Model

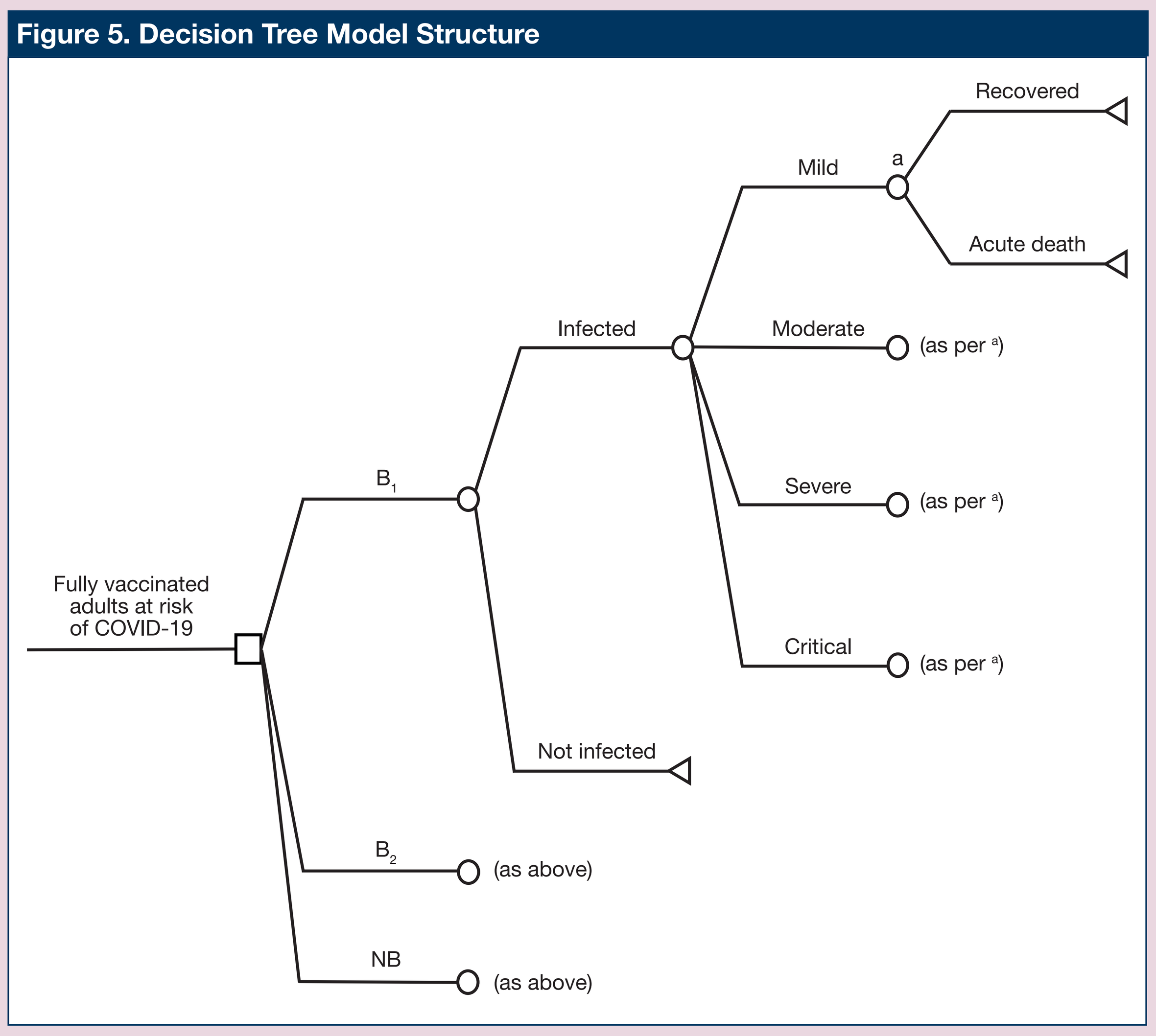
- This model identified the best BAS that could include any combination of the specified 3 booster vaccine options in the target population by age group, to meet the budgetary constraint, and minimize the key outcome, bed days (**Figure 4**).
- COVID-19 infection severity was categorized based on the World Health Organization clinical progression scale.[6]
- 2 key components were used:
  - A decision tree to estimate average cost and health outcome per individual stratified by age group over the 3-month period after receiving each booster strategy (**Figure 5**). The time period was used to align with the availability of booster effectiveness data.[3]
    - COVID-19 average 3-month attack rate for the vaccinated population was similar to to what has been seen in the Omicron era. It was calculated using real-world evidence to be 1.8%, assuming unvaccinated population to be 3 times more likely to be infected versus those with primary vaccine.[7,8]
    - Booster strategies utilized a vaccination coverage of 100%.[9]
  - An optimization routine that allocated the different strategies to minimize hospital bed days within predefined constraints.

Figure 4. Graphical Representation of CO Model



[a]Includes COVID-related costs.
B_1, booster 1; B_2, booster 2; CO, constrained optimization; HRU, healthcare resource use; NB, no booster.

Figure 5. Decision Tree Model Structure



[a]Recovered or acute death.
B_1, booster 1; B_2, booster 2; NB, no booster.

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Disclosures

EP is a market access and HTA consultant to AstraZeneca, Pfizer, BioMarin, Rhythm Pharma. SA, KB, DDT, LMO, WM and RY are employees of AstraZeneca and hold or may hold stock in AstraZeneca. RK, BS, GB, RG, KS, ET and ND were subcontracted by AstraZeneca to complete this study. TN reports personal consultancy payments for advice to AstraZeneca; support and travel for attending AstraZeneca advisory boards; DSMB appointments; and was subcontracted by AstraZeneca to complete this study.

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