

Cost-Effectiveness of Non-Pharmaceutical Interventions (NPI), Vaccines and the Combination of NPI and Vaccines in Managing the COVID Pandemic

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COVID-19 vaccinations save money and generate more QALYs through preventing infections.

When vaccines are available, lockdowns are not cost-effective, but non-pharmaceutical interventions like social distancing, mask wearing, self testing and contact tracing remain cost-effective.

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Background

To control the COVID-19 pandemic, many countries implemented non-pharmaceutical interventions (NPIs) to reduce the number of COVID-19 cases and limit the burden on the healthcare system (1). Singapore implemented a Test-Trace-Isolate (TTI) programme which involved contact tracing and routine testing, work-from-home arrangements, border closures, and a lockdown with limits to social gatherings and retail operating capacities. By the end of 2021, 85% of the Singapore population had been vaccinated against COVID-19 and a gradual relaxation of restrictions occurred. NPIs helped to manage the COVID-19 pandemic, but at a huge economic cost (2,3).

Objectives

This project evaluates the cost-effectiveness of different combinations of NPIs and vaccine availability in the Singapore community from January to December 2021 from a societal perspective.

Methods

Five scenarios were modelled (Figure 1). An SEIR disease transmission model simulated the number of COVID-19 cases and deaths in each scenario (4,5). The death rate for critical cases was doubled when the hospital ICU capacity of 350 beds was exceeded. The cost and quality-adjusted life-year (QALY) impacts for the implementation of vaccination and/or NPIs and the management of COVID-19 cases were estimated. Costs are presented in Singapore dollars (SGD) with one SGD approximating 0.74 USD in 2021.

Results

Vaccination saves money and QALYs

(Comparing scenarios (A) and (D), Table 1)

- Scenario (A) dominates Scenario (D).
- The cost of vaccination was offset by the savings from preventing COVID cases and associated reduction in TTI costs.
- The QALY loss from vaccine adverse events was offset by the QALYs saved from preventing COVID cases and death.
- Compared to NPIs without vaccination, NPIs with vaccination kept the number of critical cases within the available ICU capacity. Without vaccination, 47% of deaths were due to the ICU capacity being exceeded.
- The \$2.2 billion spent on vaccination resulted in cost savings of \$43.3 billion and 2.3 million QALYs saved.

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NPIs are cost-effective when vaccination is available

(Comparing scenarios (A) and (B), Table 1)

- With vaccination, the ICER of NPIs versus no NPI is \$3200 per QALY.
- With vaccination alone, the number of critical cases exceeded the ICU capacity and caused excess deaths.
- With both vaccination and NPIs, critical cases were manageable, and the total number of deaths was reduced by more than 90%.
- Hence, NPIs are required even if the population has been vaccinated.

Lockdown is not cost-effective when vaccination is available

(Comparing scenarios (E) and (A), Table 1)

- Lockdown incurs significant cost, notably from productivity losses due to initial transition to working from home (a component of social distancing). There was also a slight gain in QALY with ICER of \$215000 per QALY, more than 2 times of GDP per capita in 2021 (\$98 thousand).

Doing nothing incurs cost and losses QALY

(Comparing scenarios (C) and (A), Table 1)

- Scenario (C) is dominated by Scenario (A).
- Doing nothing (i.e. no vaccination and no NPI) incurs cost and loses QALY due to COVID cases that would have been prevented if there was vaccination and NPI.

Deterministic Sensitivity Analyses

Parameters on productivity losses, QALY losses, costs of vaccines and treatments, and death rates for excess deaths were varied.

- Key findings are robust and did not change.
- The two most sensitive parameters are productivity loss from isolation and QALY loss of COVID cases.
- Low estimates of QALY loss of COVID cases increased base case ICERs by tenfold.

Future Research

- To include the impact of isolation on QALY.
- To include the impact of COVID measures on delay in managing non-COVID chronic medical conditions.
- To consider the impact of exceeding not only ICU capacity but the whole hospital capacity.

References

- (1) Flaxman S, Mishra S, Gandy A, et al. Nature. 2020;584:257-261. <https://doi.org/10.1038/s41586-020-2405-7>
- (2) Mallapaty S. Nature. 2021;589:185. <https://doi.org/10.1038/d41586-020-03605-63>
- (3) Demirgüç-Kunt A, Lokshin M, Torre I. Economics of Transition and Institutional Change. 2021;29(4):551-573. <https://doi.org/10.1111/ecot.12284>
- (4) Goh FT, Chew YZ, Tam CC, et al. Epidemics. 2022;39:100581. <https://doi.org/10.1016/j.epidem.2022.100581>
- (5) Goh FT, Chew YZ, Pung R, et al. COVID-19 modelling for policy in a highly vaccinated Singapore. Manuscript submitted for Publication. 2023.

Figure 1. Summary of methods

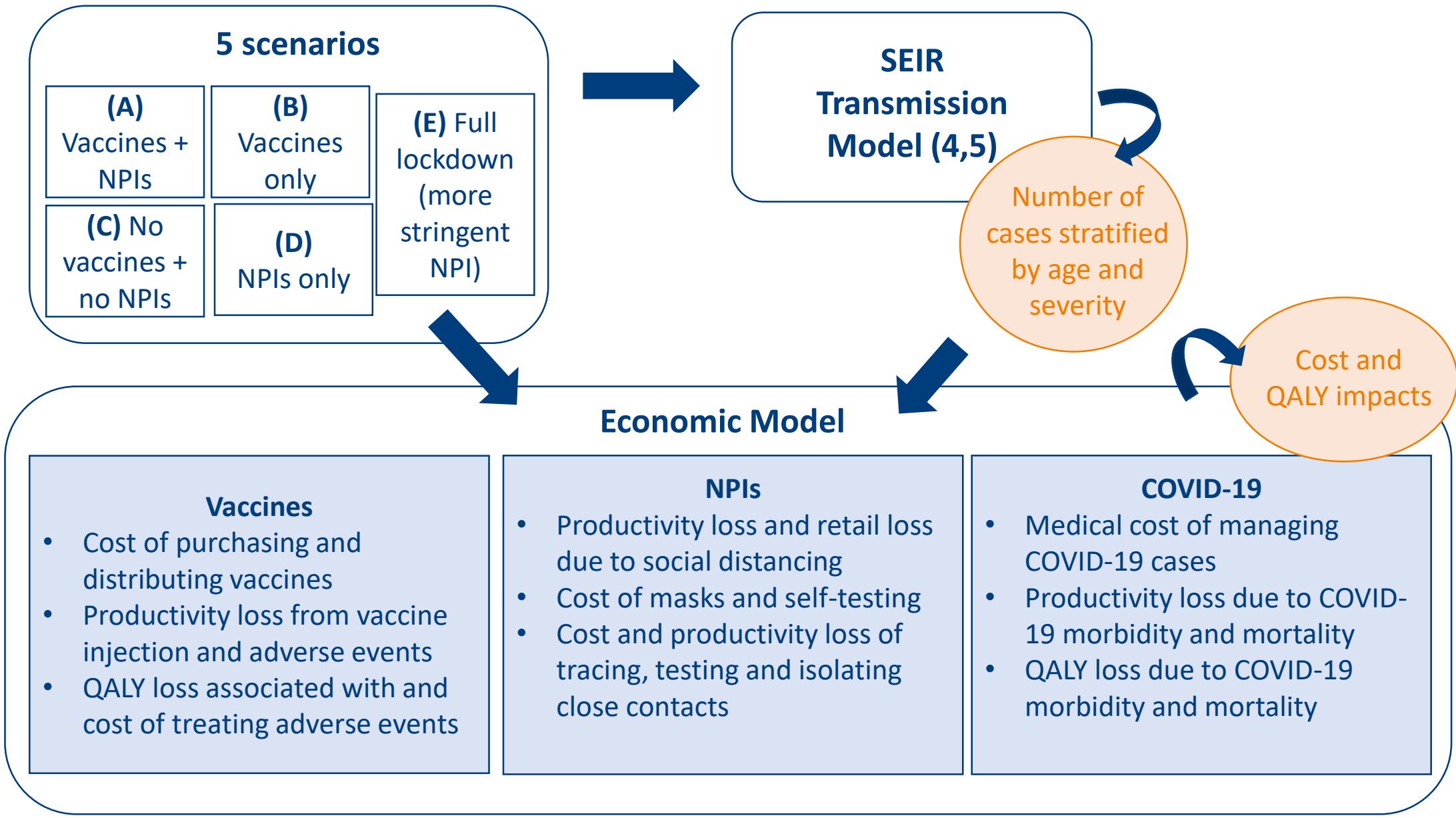


Table 1. Costs and QALYs of four counterfactual scenarios (B to E) compared to the situation in Singapore in 2021 (A)

Scenario	(A)	(B)	(C)	(D)	(E)
Vaccine availability	With vaccine	With vaccine	No vaccine	No vaccine	No vaccine
NPI stringency	NPI in 2021	No NPI	No NPI	NPI in 2021	Lockdown
Transmission Model Output					
Number of vaccine doses delivered (millions)	11.19	10.33	0	0	0
Number of COVID cases	359,882	2,411,365	3,947,739	3,897,984	0
Number of COVID deaths	693	10,644	70,496	65,611	0
~ Number of excess deaths	0	3,710	33,980	30,830	0
Comparison	(A)	(A) – (B)	(C) – (A)	(A) – (D)	(E) – (A)
Incremental Cost (millions)					
[1] Vaccination	reference	96	-2,260	2,260	-2,260
[2] Social distancing	reference	0	0	0	40,540
[3] Mask wearing	reference	613	-613	0	0
[4] Self-testing	reference	1,174	-1,174	0	-971
[5] Test-Trace-Isolate	reference	3,274	-3,274	-32,002	-3,274
[6] COVID cases averted	reference	-2,239	14,047	-13,632	-307
Total costs	reference	2,918	6,726	-43,373	33,727
Incremental QALY (millions)					
[7] Vaccine adverse effect	reference	-0.0002	0.0041	-0.0041	0.0041
[8] COVID cases averted	reference	0.9116	-2.4382	2.3628	0.1523
Total QALYs	reference	0.9114	-2.4342	2.3588	0.1563
ICER	reference	3,202	dominated	dominant	215,750

Cost and QALY values for scenarios (B), (C), (D) and (E) are incremental with reference to scenario (A), which reflects the COVID measures in Singapore in 2021. A positive cost reflects cost incurred while a negative cost reflects savings. A negative QALY reflects loss while a positive QALY reflects gain. For example, \$2.9 billion was saved with COVID cases averted while 0.9 million QALYs were gained due to COVID cases averted (Scenario (A) – (B)). NPI in 2021 includes TTI, work from home, mask wearing, and limits to social gatherings and retail operating capacity limits. Lockdown includes all measures from NPIs in 2021 plus tighter restrictions on limits to social gatherings and retail operating capacity.