When is it valuable for COVID-19 booster dose?
A transmission- dynamic- model based effectiveness and cost-effectiveness analysis of two booster dose vaccination priority strategies in mainland China

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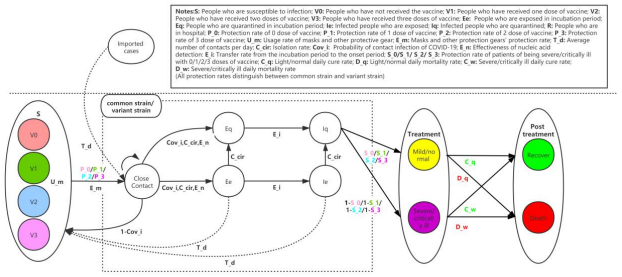
Background

- COVID-19 has had a serious impact on worldwide health and economics. COVID-19 vaccines are among the most effective methods of preventing infection.[1,2] Despite continuous mutations of SARS-CoV-2, there is evidence showing that vaccines continue to have a strong protective effect against mutant virus strains.[3]
- However, due to the decrease of vaccine protection rate and the allocation problems in many countries, controversies have inevitably arisen, for example, whether coverage for a second vaccination should be prioritized or whether vaccine booster shots in those who have received a second dose be prioritized. Currently, no study comprehensively answered this question.
- In this study, we established a unique transmission dynamics model that is based on the real situation of China's epidemic to simulate development of the epidemic in the country. Then, the effectiveness and cost-effectiveness of two vaccination strategies in China (prioritized coverage of the second shot and prioritized booster vaccination) are examined. We conducted an uncertainty analysis and propose a comprehensive, scientifically based vaccination strategy that can serve as a reference for countries outside of China that are affected by the COVID pandemic.

Methods

- In this study, a transmission dynamics model was used to evaluate three different treatment strategies for prevention of COVID-19 infections. The primary outcomes were the total number of infected cases, total number of severe cases, and costs of each strategy. A secondary outcome of interest was the number quality-adjusted life-days (QALD). Time period of this study was 180 days and the cycle length was one day. The decline in the effect of vaccine protection with time was also considered in this model.
- This transmission dynamics model mainly consists of 11 health states; the transition of these states is shown in Figure 1. All new cases of COVID-19 were assumed to be imported cases from abroad. The economic decision-making model in this study is shown in Figure 2.The corresponding paths following the major decision nodes are the same, except relevant parameters.

Figure 1 Dynamic transmission model



published literature or real-world data (e.g. Cure rate and mortality rate in mild and severe COVID-19 cases, percentage of critically ill patients, effectiveness of Vaccine). Some parameters were estimated because they have not been accurately reported (e.g. Protection rate decreases daily, cost of vaccination); we further explored these estimates in the subsequent uncertainty analysis.

- Model verification was conducted by comparing the model-simulated situation of infected cases with the real situation. Monte Carlo simulation was used with 10,000 simulations for all probabilistic parameter to obtain the results of probability sensitivity analysis. Scatter plot and cost effect acceptability curves were constructed to evaluate the results.
- We comprehensively considered the impact of various factors on the results, such as policy control and social preferences of the population. A scenario in which quarantine, face mask wearing, social distancing, and vaccination compliance interact with each other was established to analyze the impact of mass prevention measures and public policies on the results. Thus, we considered six specific scenarios base on the base case analysis in total.

Table 1 Base-case analysis results

Group	Total number of infected people	Total number of severe/critically patients	Total number of death	Incremental cost VS Control Group	Incremental cost VS Test Group 1	Incremental utility VS Control Group	Incremental utility VS Test Group 1
Ceased vaccination (Control Group)	2357	269	0				
2-dose prioritized till full vaccination (Test Group 1)	1895	181	0	36838.75 million		3128.82	
Booster dose prioritized till full vaccination (Test Group 2)	1772	208	0	36838.73 million	-12564.19	4024.53	895.71

Note: The currency unit is USD, and the utility unit is QALD.

Results

- The results of the base-case analysis obtained in the model simulation are shown in Table 1, the costs incurred are shown in Table 2. Not continuing vaccination was the most cost-effective; however, any vaccination strategy was significantly more effective than not continuing vaccination and could reduce the number of cases of infection and severe illness caused by COVID-19.
- Prioritized coverage of the second shot could significantly reduce the number of severe cases, and prioritized inoculation with the third shot could obviously reduce the number of infected cases.
- Our PSA results suggested that continuing vaccination was more effective. The scenario analysis indicated that prioritizing second shot may become more effective and beneficial with increased mask-wearing rate and nucleic acid tests requirement.

Figure 2 Economic Decision analysis Model

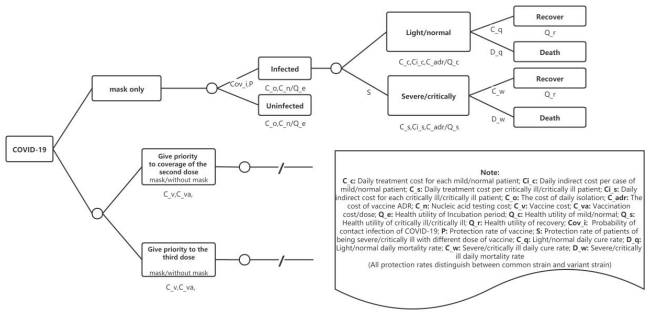


Table 2 Cost in base-case analysis

Group	Medical cost	Vaccination cost	Vaccine adverse reaction cost	Total Cost
Ceased vaccination	80.45			80.45
2-dose prioritized till full vaccination	74.9	36844.06	0.23	36919.2
Booster dose prioritized till full vaccination	74.89	36844.06	0.23	36919.19

Note: The unit is million USD

Conclusion

- We found that prioritized booster vaccination is clearly more advantageous than prioritized coverage of the second shot, i.e., fewer new infections and lower costs. However, in China, with mandatory quarantine and a high rate of wearing face masks, not continuing vaccination is more cost-effective. Thus, Booster vaccination is an imperative rather than an option in countries like China.
- In the context of the approach of expiring vaccine protection, prioritized booster vaccination in the population that has received two shots not only saves costs but also reduces infections, which is an absolute advantage. Founded on the reality of limited periods of vaccine protection against COVID-19 infection, our research results provide those countries that have relatively limited vaccines with a reference for the prioritization of vaccination.
- Wearing face masks and restricting social interactions remain the most important methods for the prevention and control of infectious diseases. Therefore, even in the case of large-scale vaccination, it is still necessary to maintain current strict anti-epidemic measures.

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Declaration of interests

The authors have no conflicts of interest to declare.

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