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The changing impact of vaccines in the COVID-19 pandemic: a modeling study

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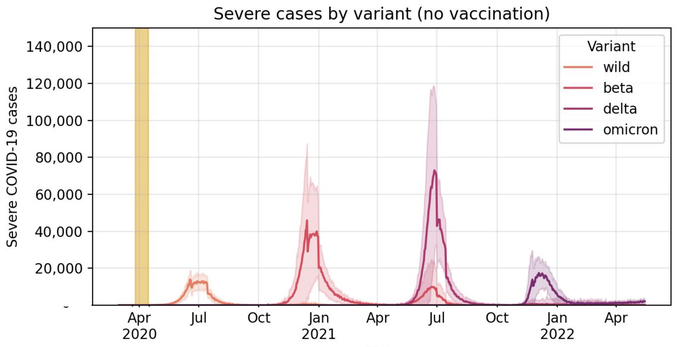
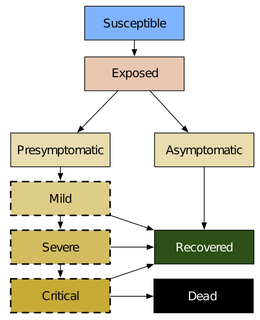
STUDY AIMS AND DESIGN

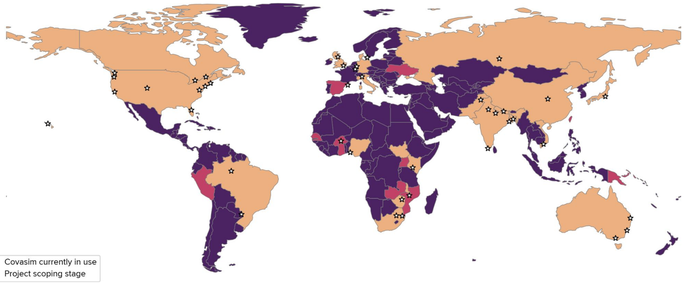
- **Goal:** evaluate the **population-level effectiveness** of COVID-19 vaccines over time and as a function of population immunity from infection.
- **Design**: agent-based modeling study using **Covasim.**
- **Setting**: simulated population representing **South Africa.**



METHODS

- **Covasim** (covasim.org) is a stochastic agent-based simulator for performing COVID-19 analyses
- Open-source, written in Python, extensively tested & documented, widely applied
- SEIRS model structure with disease transmission based on detailed, population-driven network models
- Intra-host immune model that maps neutralizing antibody (NAb) level to protective efficacy based on estimates from vaccine immunogenicity and efficacy trials + data on reinfection.

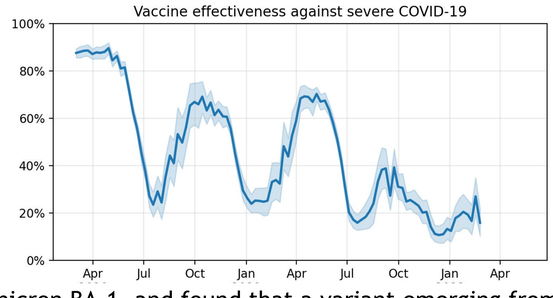




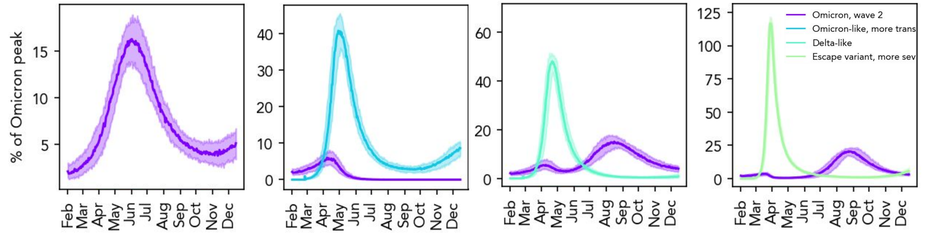
Vaccine efficacy against severe COVID-19 decreased from >90% to 20% in the wake of the first wave of COVID-19, then increased back to ~70% over 2020 as population immunity waned.

RESULTS

- Vaccine effectiveness is highest at the beginning of the pandemic & declines over time as the proportion of people with infection immunity increases.
- Within our simulated population representative of South Africa, vaccine effectiveness decreases from ~90% in the earliest stages of the pandemic to <20% in January 2022 in the wake of Omicron BA.1.
- We carried out an analysis in Jan 2022 to determine the likely impact of future variants emerging after Omicron BA.1, and found that a variant emerging from Omicron but with increased fitness advantage would compete directly with a second wave of Omicron.

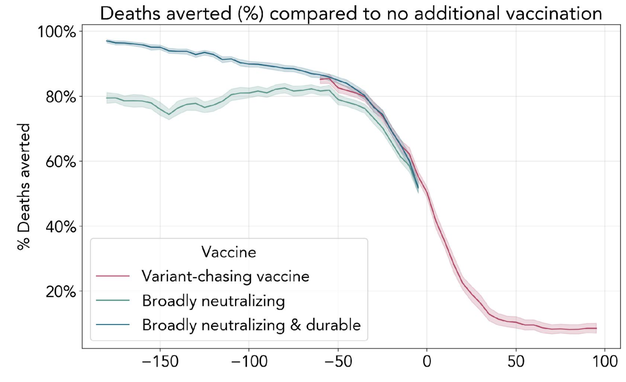


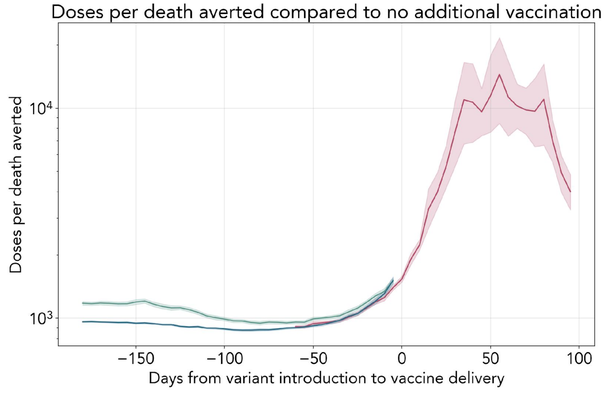
Results shown in the middle panel are closest to what ensued in reality, with South Africa experiencing a new wave of infections in May 2022 that peaked at 25% the value of the peak of BA.1 infections.



CONCLUSIONS

- Our results have implications for the likely efficacy of variant-chasing vaccine strategies. We estimate a ~five-week window where developing & deploying a variant-specific vaccine could avert >50% of deaths, a 2.5-fold higher impact with the current vaccine.
- A variant-chasing strategy would avert more deaths than current vaccines at the same coverage levels until ~3 weeks after the introduction of the new variant into a population. A broadly neutralizing and durable vaccine could avert ~80% of deaths caused by a highly immune evading, virulent variant if delivered over a month before a new variant emerges.
- While this strategy may have limited impact in the countries in which a variant emerges, it may be a globally effective solution, especially if paired with temporary non-pharmaceutical interventions.





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REFERENCES: Cohen et al (2023); Kerr et al (2021)