How a simulation is informing COVID-19 vaccine policy after our 'return to normal'

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As the saying goes "There is no such thing as normal" and this has been especially true after the pandemic.

Before the emergence of the omicron COVID-19 variant, countries like the U.K. had high vaccination coverage along with widespread exposure to COVID-19 in the population.

This combination of vaccine and infection-derived immunity is termed hybrid immunity and is different to vaccine immunity or infection immunity alone.

In contrast, other countries, including Australia, New Zealand and those in the Western Pacific, had a very different pandemic experience. These countries and regions had low prior exposure and differing levels of vaccination.

The widespread waves of COVID-19 that followed the emergence of the omicron variant in late 2021 completely changed the immune landscape.

Omicron sharply increased COVID-19 exposures across the world, including in the Western Pacific Region which previously had low exposure.

Now, there is a complex global situation where populations in different countries have unique hybrid immunity landscapes, born from a wide range of vaccination history and exposure history combinations.

In 2023, we needed to consider what hybrid immunity meant for booster vaccinations. And what different types of hybrid immunity meant for future vaccination strategies.

Because while countries were "returning to normal," SARS-CoV-2 hadn't gone away. We needed a systematic way to make population-level recommendations and support government decision-making on a global scale.

What is hybrid immunity?

We gain hybrid immunity from a combination of COVID-19 vaccinations and past infections. When a population goes through various COVID-19 waves and cycles of vaccination, the population acquires a complex hybrid immune landscape—and this is the current state in countries around the world.

Hybrid immunity can prevent future infection and reduce the severity of outcomes. We were particularly interested in what this means for future waves of COVID-19 and the implications on future vaccine strategies.

Given competing health priorities and resource constraints, governments and policymakers need to assess their future vaccination policies. After all, if a population already has high immunity derived from infection, are vaccinations still required?

Our modeling helps us answer this question, finding that yes, vaccinations are still important on the population level, but they will likely be used in a different way in future.

How do we answer vaccine policy questions?

Our model is an "agent-based model," where we simulate thousands of "individuals," each with their own vaccination and infection histories.

With a focus on the Western Pacific Region, we configured the model to a range of exemplar populations in the region, accounting for prior immunity and vaccination coverage (ranging from high to low), and population age structure (older versus younger age demographics).

Then, by running the model "into the future," under various scenarios regarding COVID-19 variants and vaccine coverage, we tested what could happen, given different historical settings (hybrid-immunity levels) and the future emergence of new variants.

What did the model find?

The strongest benefit of COVID-19 vaccines is their protection against severe outcomes, including hospitalization. In contrast, they have limited efficacy against transmission between infected and non-infected people.

Our results suggest that populations with low vaccination coverage and high past infection rates should still consider vaccination if public health measures are not enforced or social mixing is not reduced, with particular emphasis on protecting those at higher risk, such as older age groups.

How did this impact vaccine policy globally?

Modeling can help us understand ongoing COVID-19 waves, including the likely impact of responsive vaccine interventions, and how vaccinations will continue to play a key role in keeping people healthy and safe.

Using this work as a springboard, we extended it in response to a request for data modeling from the World Health Organization (WHO) Strategic Advisory Group of Experts on Immunization (SAGE) Working Group on COVID-19.

We evaluated the cost-effectiveness of vaccination strategies across a range of settings considering (largely) unvaccinated low- and middle-income countries (LMICs) and well-vaccinated countries.

These results fed into the global policy decisions through the WHO's SAGE Group and their Immunization and Vaccine-related Implementation Research Advisory Committee (IVIR-AC).

In particular, our modeling informed WHO's revised (March 2023) recommendations for COVID-19 booster vaccination to achieve equitable health outcomes.

What now?

COVID-19 continues to circulate in the global population. However, competing health priorities and resource constraints mean governments and policymakers must carefully consider if, when, and who to vaccinate.

Complex and diverse immune landscapes and global needs make it difficult to guide broad policy on vaccine decision-making.

Our flexible framework can consider different country contexts by inputting different age distributions, vaccination schedules, contact matrices and other key parameters to help determine the relative benefits of potential vaccine programs in different populations.

This information helps support individual countries in deciding what part vaccines will play in protecting populations against emerging variants of concern.

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