Pre-existing Population Immunity and SARS-CoV-2 Variant Dynamics in the United States: An Ecological Study

Pierre Ankomah[1,2], Mark Siedner[1], Roby Bhattacharyya[1,2]

1. Department of Medicine, Division of Infectious Diseases, Massachusetts General Hospital, Boston, MA, USA
2. The Broad Institute of MIT and Harvard, Infectious Diseases and Microbiome Program, Cambridge, MA, USA

Background

- State-level variation in SARS-CoV-2 immunity in the USA can facilitate evaluation of how population immunity affects new variant displacement of older variants (variant takeover).
- Delta and Omicron variants of SARS-CoV-2 are more immune-evasive relative to strains that were circulating prior to their emergence.
- **Hypothesis: if immune evasion is a major driver of variant fitness, Delta and Omicron would have faster takeover in states with more population immunity.**

Methods

- We accessed SARS-CoV-2 variant data submitted to GISAID from first detection of Delta or Omicron in a state, until each consistently represented >99% of all genomes.
- We computed the proportion of each emerging variant among total SARS-CoV-2 sequences as a 7-day average.
- We fit asymmetric logistic growth curves to changes in variant proportion over time.

Logistic curve fits facilitate assessment of variant takeover

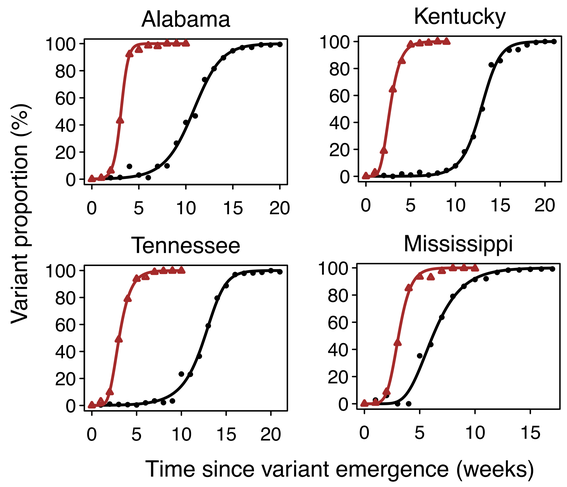

Fig 1. Logistic curve fits to weekly estimates of Delta (black circles) or Omicron (red triangles) proportion of all SARS-CoV-2 isolates in a state. East South Central geographic region shown.

Evaluation of variant takeover

- **Takeover rate**: maximum slope of the logistic curve
- **Date of takeover/dominance**: the calendar date variant proportion exceeds 50%
- **Time from establishment to dominance**: time for variant proportion to increase from 10% to 50%

Evaluation of population immunity

- Using CDC data, we estimated statewide immunity **from** the **proportion of individuals either previously infected with SARS-CoV-2 or fully vaccinated/boosted** prior to variant takeover.
- In primary analysis, we estimated vaccine-induced immunity from the most effective vaccine series available during variant takeover.

Linear regression models to evaluate the relationship between variant takeover and state immunity

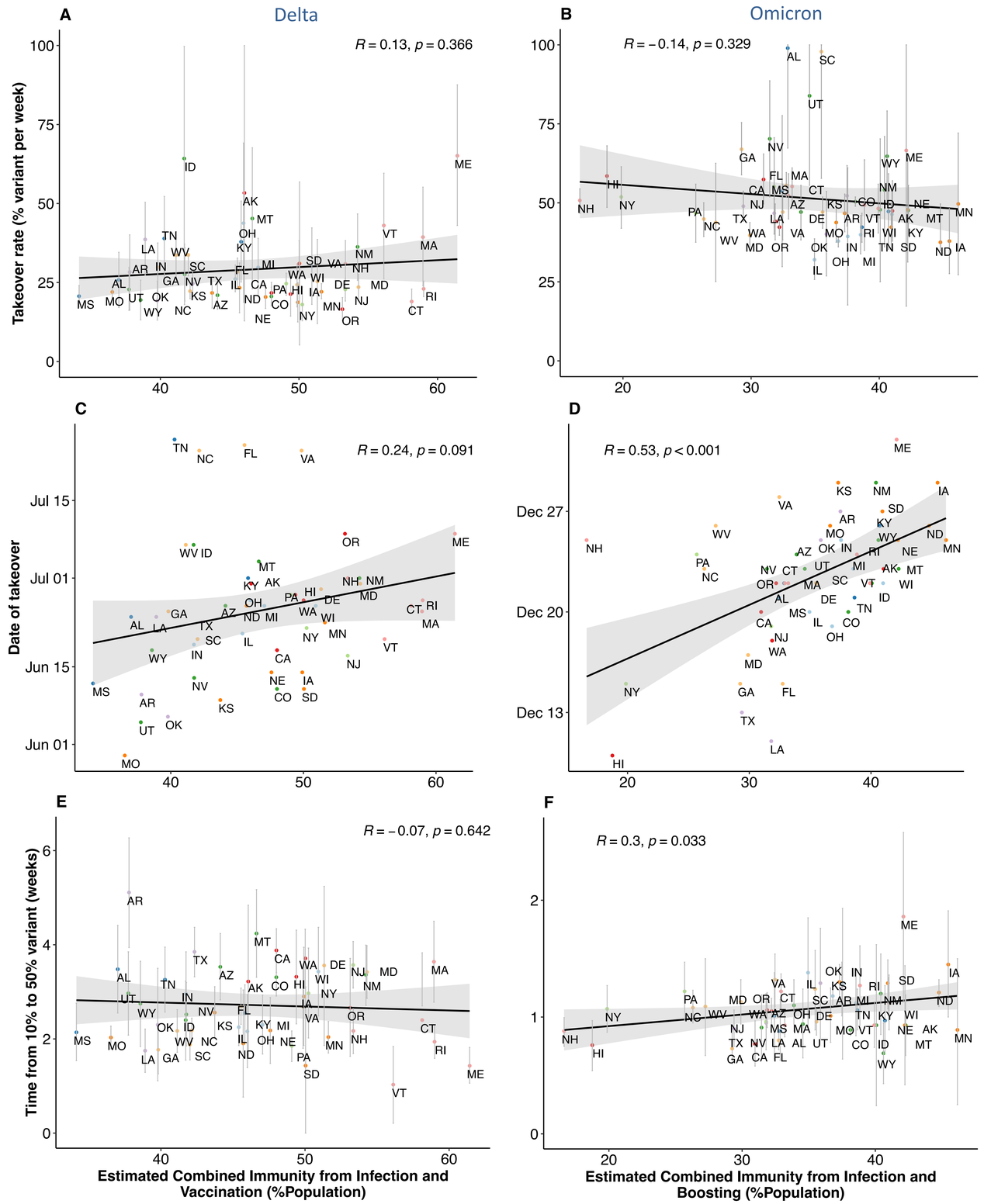

Fig 2. Delta (left) and Omicron (right) takeover in US states. Estimated maximum takeover rates (A,B), calendar dates at which a variant reached 50% of sequenced SARS-CoV-2 genomes (C,D), and time for variant proportion to increase from 10% to 50% of sequenced SARS-CoV-2 genomes. Immunity is estimated by the combined proportion of a state's population with identified SARS-CoV-2 infection and either fully vaccinated (for Delta) or boosted (for Omicron) prior to detection of the new variant in the state . Linear regressions (black), 95% confidence intervals (gray), Pearson correlation coefficient (R) and p-values shown for individual plots. States are identified by standard two-letter abbreviations.

Major Results

- No statistically significant relationship between variant takeover rates and immunity (Fig. 2a,b).
- Omicron takeover occurred at later dates in states with more immune populations, with a similar, but not statistically significant trend for Delta (Fig. 2c,d).
- Variant establishment to dominance took longer in states with higher population immunity for Omicron, but not for Delta (Fig. 2e,f).

Conclusions

- **Emerging immune-evasive variants (Delta and Omicron) had similar takeover rates and similar or later time to dominance in US States with greater estimated population immunity.**
- Our findings do not support theoretical concerns about enhanced selection for immune-evasive variants as a drawback of widespread vaccination campaigns.

Caveats/Limitations

- GISAID data on variant proportions is a selected sample whose depth and representativeness may vary by state.
- Public case reporting data underestimates total infection rates, possibly to varying extents in each state.
- We assume an independent relationship between vaccination- and infection-induced immunity.
- We do not account for the waning of vaccine-induced immunity.
- Public health policies and other confounders may vary by state and affect both acquisition of immunity and variant transmission.

Poster QR Code

Preprint QR Code

Bhattacharyya Lab
Est. 2019

medRxiv
THE PREPRINT SERVER FOR HEALTH SCIENCES