Results of Studies Evaluating the Impact of SARS-CoV-2 Variants of Concern on COVID-19 Vaccines: An Ongoing Systematic Review

Neutralization Plots

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Methods for Inclusion in Neutralization Plots

The studies included in the plots below were identified as part of an ongoing systematic review of studies evaluating the impact of SARS-CoV-2 variants of concern on COVID-19 vaccine performance. Studies from March 15, 2021 onward that report fold reductions in neutralization or that report data that enable the calculation of fold reductions in neutralization are included.

The following studies are not included:

- Studies evaluating partial vaccination
- Studies that collected vaccinee sera < 7 days or > 6 months post final vaccine dose
- Studies that used a variant of concern (e.g. Alpha, Delta) as the reference strain
- Studies of immunocompromised persons
- Studies including samples from persons with hybrid immunity
- Studies using surrogate neutralization assays
- Studies that combine vaccines (with the exception of mRNA vaccines for all VOCs other than Omicron)
- Studies that ND80 results instead of ND50

The WHO COVID-19 Weekly Epidemiological Update is posted weekly on the WHO website (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports). A summary of results from these studies by vaccine and by variant of concern are provided in the WEU every other week.

For any questions, comments, or suggestions about this document, please contact Melissa Higdon: mhigdon@jhu.edu.
## Primary Series Vaccines

### Fold Reduction in NAbs by SARS-CoV-2 Variant of Concern and Vaccine Platform, Box Plot

<table>
<thead>
<tr>
<th>Variant</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
<th>Delta</th>
<th>Omicron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inactivated mRNA</td>
<td><img src="box_plot_alpha_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_mRNA.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>Inactivated protein subunit</td>
<td><img src="box_plot_alpha_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_protein.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>Inactivated + vector</td>
<td><img src="box_plot_alpha_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_vector.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>mRNA</td>
<td><img src="box_plot_alpha_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_mRNA.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>Protein subunit</td>
<td><img src="box_plot_alpha_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_protein.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_protein.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>Vector</td>
<td><img src="box_plot_alpha_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_vector.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_vector.png" alt="Box Plot" /></td>
</tr>
<tr>
<td>Inactivated + vector + mRNA</td>
<td><img src="box_plot_alpha_inactivated_vector_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_beta_inactivated_vector_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_gamma_inactivated_vector_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_delta_inactivated_vector_mRNA.png" alt="Box Plot" /></td>
<td><img src="box_plot_omicron_inactivated_vector_mRNA.png" alt="Box Plot" /></td>
</tr>
</tbody>
</table>

*Vaccine Platform:
- Inactivated
- mRNA
- Protein subunit
- Vector
- Inactivated + vector
- Inactivated + vector + mRNA

*Note: The box plots show the fold reduction in neutralizing antibodies (NAb) for different vaccine platforms across various SARS-CoV-2 variants.*
Booster Doses

Fold Reduction in NAbs by SARS-CoV-2 Variant of Concern and Vaccine Platform, Box Plot: Booster Doses

<table>
<thead>
<tr>
<th>Vaccine,Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>inactivated (all doses)</td>
</tr>
<tr>
<td>mRNA (all doses)</td>
</tr>
<tr>
<td>protein subunit (all doses)</td>
</tr>
<tr>
<td>vector (all doses)</td>
</tr>
<tr>
<td>inactivated + mRNA booster</td>
</tr>
<tr>
<td>inactivated + protein subunit booster</td>
</tr>
<tr>
<td>vector + mRNA booster</td>
</tr>
<tr>
<td>vector + protein subunit booster</td>
</tr>
</tbody>
</table>

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PREPARED BY HENNING JACOBSEN, IOANNIS SITARAS, MELISSA HIGDON, ET. AL
Fold Reduction in NAbs by SARS-CoV-2 Variant of Concern and Vaccine Platform, Violin Plot: Booster Doses

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<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
<th>Delta</th>
<th>Omicron</th>
</tr>
</thead>
</table>

Vaccine Platform:
- inactivated (all doses)
- mRNA (all doses)
- protein subunit (all doses)
- vector (all doses)
- inactivated + mRNA booster
- inactivated + protein subunit booster
- inactivated + vector booster
- mRNA + vector booster
- vector + mRNA booster
- vector + protein subunit booster

No reduction