Modelling potential impacts of SARS-CoV-2 variants of concern

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What can mathematical models tell us?

- Mathematical models may be used to assess sensitivity to parameter assumptions and convey uncertainty.

- We investigate two ways in which variants may be concerning:
  - they may be more transmissible;
  - that they may evade immunity (infection- or vaccine-derived).

**Table:** Transmissibility and immune escape properties for illustrative VOC scenarios.

<table>
<thead>
<tr>
<th>Description</th>
<th>Relative transmissibility</th>
<th>Proportional vaccine efficacy</th>
<th>Proportional prior-infection efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC MT</td>
<td>More transmissible</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>VOC E</td>
<td>Immune escape</td>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>VOC LT+E</td>
<td>Less transmissible and immune escape</td>
<td>0.8</td>
<td>0.75</td>
</tr>
</tbody>
</table>
(1) Exploring parameter space and discerning general principles
• Analysed using a parsimonious deterministic compartment model with homogeneous mixing.

(2) Potential effects of variants on burden of severe cases
• Deterministic compartmental model with age-structure, matched to epidemiological data in the UK.

(3) Timing of VOC targeted vaccines
• Parsimonious model with a VOC targeted vaccine.
Talk outline

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Model schematic
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Model schematic

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Simulation overview

- **Population**: 56 million.
- **Time horizon**: Beginning 10th May 2021, for 365 days.
- **VOC initial infecteds**: Introduce 1,000 VOC infected into the system on 1st June 2021.
- **NPIs**: Level of NPIs acting on the population is captured by “R excluding immunity”, which increases on the earliest date each step of the relaxation Roadmap may be enacted.
- **Vaccination**: Vaccine action acts to prevent infection.
VOC transmission dynamics

**Figure:** Vaccination uptake and the impact of assumed level of NPIs through time.
VOC transmission dynamics

Figure: Temporal profiles of the infectious prevalence for the illustrative VOCs.

- Novel variants can lead to waves of infection beyond what we would expect from the wildtype (B.1.1.7).
Sensitivity to VOC assumptions

**Figure:** Sensitivity of epidemiological measures to relative transmissibility of the VOC versus the wildtype variants and proportional efficacy (vaccine and natural-immunity) against the VOC.
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Warwick SARS-Cov-2 transmission model

Vaccination and non-pharmaceutical interventions for COVID-19: a mathematical modelling study
Moore et al. (2021)
Lancet Infectious Diseases.
Even though the vaccines protect against severe infection, the number of infections can be high, and so the number of hospitalisations can be high.
An early signal of whether a variant has immune escape or higher transmissibility may be given by looking at the age distribution of cases.
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**VOC targeted vaccines**

**Figure:** Infectious prevalence dependence upon introduction date of a vaccine targeted against a novel VOC with immune escape properties (equal transmissibility to wildtype, proportional vaccine & prior-infection efficacy of 0.75).

- An earlier introduction of a vaccine with improved efficacy against the novel VOC can lessen and delay the peak in infection.
VOC targeted vaccines

**Figure:** Sensitivity of epidemiological measures to the deployment date of a VOC targeted vaccine relative to the seeding of VOC infecteds and relative transmissibility of the VOC.

- Increased relative impact of earlier VOC targeted vaccine introduction date for VOCs that are less transmissible than the wildtype variant.
Exploring parameter space and discerning general principles

- Novel variants can lead to waves of infection beyond what we would expect from the wildtype.
- Can occur even if the novel variant is not more transmissible than the wildtype, if it has immune escape.

Potential effects of variants on burden of severe cases

- Even though the vaccines protect against severe infection, the number of infections can be high, and so the number of hospitalisations can be high.

Timing of VOC targeted vaccines

- Variable impact, dependent upon lag until it is available, how much more transmissible the VOC is and the improvement in efficacy.
Acknowledgements

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