Know-C19

A policy, health and implementation response to COVID-19

COVASIM modelling: Impact of vaccines on epidemic outcomes | 11 June 2021

Projected epidemic outcomes for COVID-19 strains against different vaccine rollouts

COVASIM is an agent-based COVID-19 model developed by Burnet Institute (Australia) and Institute for Disease Modelling (USA) [1] and calibrated to Victoria, Australia [2-4]. Model scenarios have been run to help answer the question: ***What is the impact of different levels of vaccine coverage, if public health control measures were stopped and the virus was allowed to spread through the community?***

Burnet Institute has developed an Excel-based tool that summarises thousands of simulations of different scenarios. In each scenario, new infections (one per day) begin to be introduced to the Victorian community at some point following the commencement of vaccine rollout. The vaccine rollout is assumed to continue at a fixed rate with increasing coverage every week. The tool can compare outcomes when different COVID-19 strains are introduced, and vaccine efficacy assumptions are varied.

Before using the tool or interpreting outcomes it is critical that the following key points and examples are read and understood. For additional information, or advice in interpretations, please contact the authors.

Critical points for understanding these projections

- The scenarios assume a user-defined vaccine rollout speed of either 150,000 or 250,000 doses per week in Victoria (75,000 or 125,000 vaccinated people per week, due to second doses). The results are different if the rate of vaccine rollout is different.
- The scenarios do not currently include any major public health response to gain control of outbreaks. On detection of the first case, the model assumes symptomatic testing increases (isolation of positive cases continues), masks become recommended but not mandatory, and contact tracing continues but only up to 250 diagnoses per day. Hence the projections represent hypothetical near-worst-case scenarios.
- The results are based on a collection of model assumptions about the contacts of individuals and disease transmission dynamics [3]. If these best-estimate assumptions are optimistic or pessimistic, then compared with these projections actual epidemic outcomes will be more optimistic or pessimistic respectively.

Example interpretations

Scenario 1 (S1; blue bars)

- The virus strain (original strain) has the same infectiousness as the Victorian second wave, the vaccine has 50% efficacy at preventing infection with this strain, and an optimistic maximum vaccine coverage of 95% among all ages can be achieved.
- If cases are introduced to the community at random, with a vaccine rollout speed of 250,000 doses per week, there is a "race" between the time lag before a single case expands into an outbreak (noting that not all introduced cases result in an outbreak) and the time until vaccination coverage is sufficient to reach a herd immunity threshold.
- If one case per day were introduced starting from 0% vaccine coverage (i.e. at the same time the vaccine rollout began), there would be an estimated ~3 million infections and ~2,000 deaths over the following 12 months (Fig1, blue). However, if cases started to be introduced when 60% vaccine coverage was reached, this would give the vaccine coverage a head start, and herd immunity could be reached before an outbreak takes off (Fig1, blue).
- For the original strain / vaccine combination and vaccine rollout speed, this model suggests that once 60% vaccine coverage is achieved then testing, contact tracing and isolation of positive cases may be sufficient to prevent uncontrolled outbreaks.
- Importantly, these findings are specific to the strain infectiousness, vaccine efficacy and achievable vaccine coverage parameters used in this scenario. Also, as outlined above, no public health responses are introduced to control the outbreak.

Scenario 2 (S2; orange bars):

- Scenario 1, except with a maximum vaccine coverage of 95% among people >60 years and 70% among people <60 years.
- This is no longer sufficient to achieve herd immunity. Even if cases start to be introduced when the rollout is almost complete >2 million infections occur (Fig1, orange)
- Note the 80% and 90% orange bars are missing because this level of coverage is not possible in this scenario.

Authors: Romesh Abeysuriya, Margaret Hellard, Nick Scott

For further information please contact:

Dr Nick Scott, Head, Modelling Working Group, Burnet Institute. E: nick.scott@burnet.edu.au

Professor Margaret Hellard, Deputy Director, Burnet Institute. E: margaret.hellard@burnet.edu.au

Dr Romesh Abeysuriya, Senior Research Officer, Burnet Institute. E: romesh.abeysuriya@burnet.edu.au

Burnet Institute
Medical Research. Practical Action.

Scenario 3 (S3; grey bars):

- The virus is 1.5 times as infectious as the original strain (i.e., approximating the B.1.1.7 strain / UK variant), the vaccine has a 50% efficacy at preventing infection with this strain, and an optimistic 95% vaccine coverage can be achieved among all ages.
- Due to the greater virus infectiousness, with 50% vaccine efficacy for preventing infection, herd immunity is not achieved. Even with 90% vaccine coverage before cases are introduced there were ~2 million infections within 12 months (Fig1, grey).
- Of note, because the vaccine is effective at preventing disease, the estimated number of deaths are greatly reduced.
- As long as vaccine coverage reaches 60% before cases start to be introduced, mortality projections are stable. This is because in the model the vaccine is targeted according to age (i.e., 60% overall coverage includes 95% coverage among people over 60, before younger groups start to be vaccinated).
- Waiting until at least 60% vaccine coverage is achieved could save lives (providing this vaccine rollout speed were maintained).
- However, for this virus strain/vaccine combination + optimistic highly achievable coverage scenario, if the virus regularly enters the community it is likely to result in >2,000 deaths.
- As with Scenarios 1 and 2, no public health responses are introduced to control the outbreak.

Table 1: example model parameters. Note: these parameters do not reflect any data on vaccines and are for illustrative purposes only.

Parameter description	S1	S2	S3
Multiplier for transmission per contact (relative to second wave calibration)	1	1	1.5
Vaccine efficacy: prevention of infection	50%	50%	50%
Vaccine efficacy: prevention of symptoms (given infection)	50%	50%	50%
Vaccine efficacy: prevention of hospitalisation given symptoms	50%	50%	50%
Vaccine efficacy: prevention of ICU given hospitalisation	25%	25%	25%
Vaccine efficacy: prevention of death given ICU	25%	25%	25%
Number of vaccine doses per week	250000	250000	250000
Maximum vaccination coverage achieved (over 60s / under 60s)	95_95	95_70	95_95

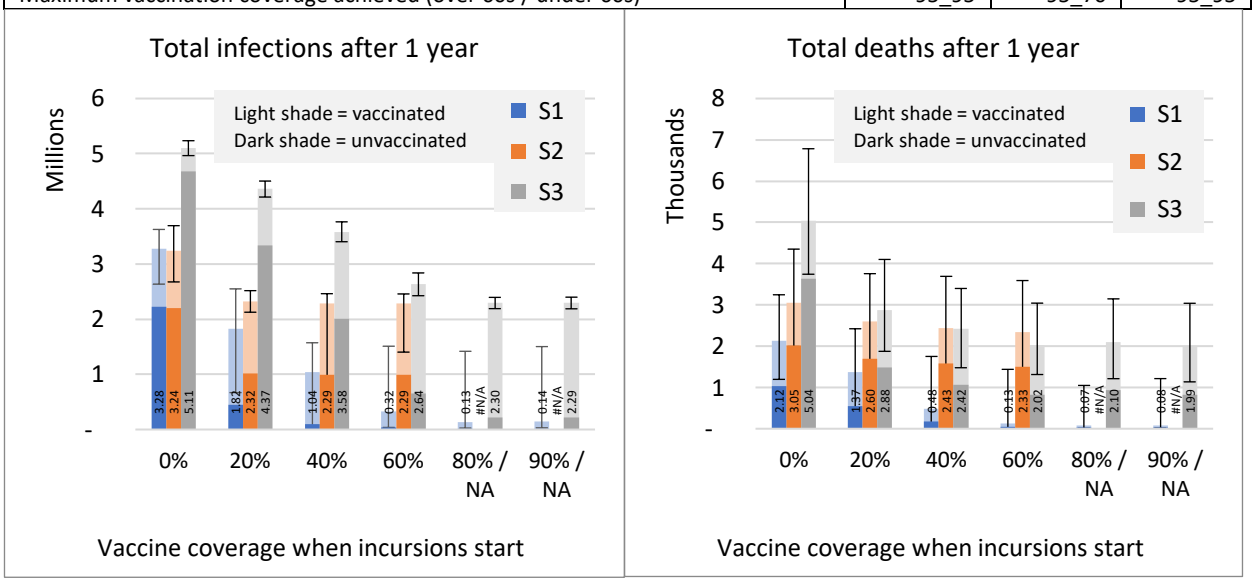

Figure 1: Total infections (left) and deaths (right) in Victoria if one new infection per day were introduced to the community at random, starting at different stages of the vaccine rollout (x-axis). *NB: When incursions start with 0% vaccination coverage, some people in the scenarios are vaccinated prior to becoming infected due to the 'lag' between cases being introduced and their infection.*

References

1. Kerr C, Stuart RM, Mistry D, Abeysuriya RG, Hart G, Rosenfeld K, Selvaraj P, Núñez RC, Hagedorn B, George L *et al* : **Covasim: an agent-based model of COVID-19 dynamics and interventions**. *medRxiv* 2020, **doi:10.1101/2020.05.10.20097469v1**.
2. Scott N, Palmer A, Delport D, Abeysuriya R, Stuart R, Kerr CC, Mistry D, Klein DJ, Sacks-Davis R, Heath K *et al* : **Modelling the impact of reducing control measures on the COVID-19 pandemic in a low transmission setting.** *Med J Aust* 2020, **214**(2):79-83.
3. Abeysuriya RG, Delport D, Stuart RM, Sacks-Davis R, Kerr CC, Mistry D, Klein DJ, Hellard M, Scott N: **Preventing a cluster from becoming a new wave in settings with zero community COVID-19 cases**. *medRxiv* 2020, doi:10.1101/2020.12.21.20248595.
4. Abeysuriya R, Delport D, Hellard M, Scott N: **Estimating risks associated with early reopening in Victoria. Policy brief. Available from:** https://www.burnet.edu.au/projects/467_covasim_modelling_covid_19. Sep 2020.