Tradeoff between population immunity and return-to-work for COVID-19 control

Autumn and Winter 2021 Scenarios

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Summary

Methods

1. We use the "Ready Reckoner" framework[1] to estimate possible reproduction numbers, numbers of cases and numbers of deaths in Autumn/Winter 2021. The model is a national-scale model for Great Britain (assumed population size 67 million), although regional models, or estimates for other DAs (e.g. Wales) have been developed, so we could provide subnational or DA estimates.

2. We've assumed a baseline basic reproduction number of 7 and consider scenarios with no COVID-security or contact tracing and with a 25% efficacious COVID security and contact tracing.

3. A major change from the previous version is that we now use ONS modelled antibody prevalence[2] to capture immunity from natural infection, vaccination, and waning protection, instead of explicitly modelling vaccine rollout. We assume that the maximum vaccine effectiveness would operate if 100% of the population had COVID-19 antibodies; any reduction from this level results in reduced population protection.

4. We consider four scenarios applied sequentially:

    a. Baseline, using ONS antibody estimates by single year of age from 29 August 2021.

    b. A booster programme: assuming that antibody levels reach maximum observed levels.

    c. Vaccinating 12- to 15-year-olds with a 65% uptake.

    d. A vaccine escape variant of concern resulting in a 20% drop in protective immunity in the population.

5. We consider return-to-work versus working from home by switching on and off a proportion of work and leisure contacts.

Results

6. With $R_0 = 7$, we estimate that with a full return to pre-COVID contact patterns, and 0% COVID-security, the effective reproduction number would be between 1.1 and 1.6. The total number of cases would be between 5.7 million and 6.3 million and the number of deaths would be between 7,500 and 9,100.

7. We estimate that including a booster programme would reduce the reproduction number to 1.0—1.5, the number of cases to 4.9 million – 5.4 million and the number of deaths to 5,200 – 6,300.

8. Adding vaccination of 12-to-15-year-olds would reduce the reproduction number to 0.9—1.3, the number of cases to 3.4 million – 3.8 million and the number of deaths to 3,200 – 3,800.

9. Finally, considering a vaccine escape variant of concern has the potential to massively increase the reproduction number and number of cases: with a 20% reduction in protection, we found $R =$1.7 – 2.3, numbers of cases 21 million – 22 million and numbers of deaths 91,000 – 106,000.

10. Retaining some home working can reduce the reproduction number to less than 1 and result in many fewer cases and deaths.

11. Retaining some levels of COVID-security (i.e. face coverings and social distancing) and contact tracing also reduces baseline estimates.

Limitations

12. This framework is only able to estimate final sizes and cannot capture the epidemic profile (including the peak burden of cases) or changes in epidemiology and immune waning over time.

13. This methodology is most appropriate when the reproduction number is greater than 1. When the reproduction number is close to 1, small changes in parameter estimates can result in large changes in outcomes.

14. The results are dependent on the estimates of vaccine effectiveness.

Methods

The methods for estimating the reproduction number and final sizes are the same as presented previously[3]. The main change is the way in which include the effects of immunity.

We replaced the vaccination scenarios with the ONS antibody data by single year of age. Our rationale for doing this was to increase the simplicity of the modelling framework and increase the reliance on data rather than introducing additional parameters to capture the interaction between vaccination, natural infection and waning of protection.

Scenarios

Baseline

We use ONS modelled percentage of individuals with antibodies by single year of age to capture immunity in the population. For each individual, their susceptibility is multiplied by a factor $1 - v_s \delta_a$, where v_s is the reduction in infection due to full vaccination and δ_a is the proportion of age group a that has antibodies to COVID-19. Their infectiousness is multiplied by a factor $1 - v_t \delta_a$, where v_t is the reduction in transmission due to full vaccination, and their personal death rate is multiplied by a factor $1 - v_d \delta_a$, where v_d is the reduction in death due to full vaccination. Mean values are given in the table below, and for each individual we sample from a normal distribution with standard deviation equal to 2% of the mean.

	Protection afforded by antibody response
Mortality v_d	**95%**
Infection v_s	**70%**
Transmission v_t	**60%**

We use ONS estimates of the percentage of the population with detectable antibody levels on 29 August 2021 broken down by single year of age, and additionally assume that levels have decreased since the survey by a further 2% to capture waning immunity. We assume under 16-year-olds have the same antibody levels as 16-year-olds.

We take a baseline basic reproduction number of 7 and include COVID security and contact tracing at 0% and 25%.

Boosters

We model vaccine boosters for people over 50 by setting the proportion antibody positive δ_a to the maximum recorded value between 5 July 2021 and 29 August 2021.

Vaccinating 12-to-15-year-olds

We assume that vaccinating 12-to-15-year-olds increases the percentage of that age group with antibodies to 65%. All other assumptions as the boosters.

Vaccine escape variant of concern

In addition to booster vaccines and vaccinating 12-to-15-year-olds, we consider a reduction in protective antibody levels by 20%.

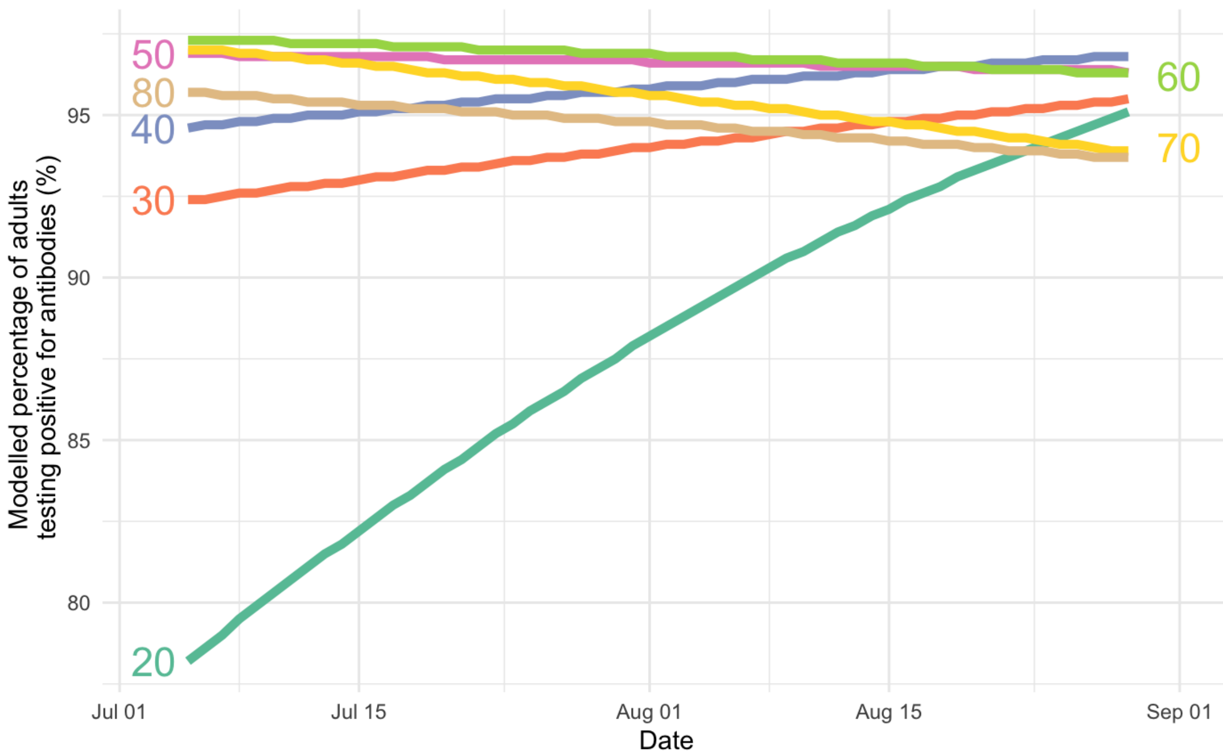

Figure 1: Modelled proportion of adults testing positive for antibodies over time, taken from the ONS.

Table 1: Modelled proportion of adults testing positive for antibodies for the four scenarios.

Age	Baseline	Booster	12-15 yo vaccination	VOC
11 and under	54.2	54.2	54.2	43.4
12	54.2	54.2	65.0	52.0
13	54.2	54.2	65.0	52.0
14	54.2	54.2	65.0	52.0
15	54.2	54.2	65.0	52.0

16	54.2	54.2	65.0	52.0
17	67.6	67.6	67.6	54.1
18	78.9	78.9	78.9	63.2
19	86.5	86.5	86.5	69.2
20	90.3	90.3	90.3	72.3
21	92.1	92.1	92.1	73.6
22	92.7	92.7	92.7	74.2
23	92.9	92.9	92.9	74.3
24	92.8	92.8	92.8	74.3
25	92.6	92.6	92.6	74.1
26	92.2	92.2	92.2	73.8
27	91.8	91.8	91.8	73.4
28	91.3	91.3	91.3	73.0
29	90.9	90.9	90.9	72.7
30	90.7	90.7	90.7	72.6
31	90.6	90.6	90.6	72.5
32	90.8	90.8	90.8	72.7
33	91.0	91.0	91.0	72.8
34	91.3	91.3	91.3	73.0
35	91.6	91.6	91.6	73.3
36	91.8	91.8	91.8	73.4
37	91.9	91.9	91.9	73.5
38	92.0	92.0	92.0	73.6
39	92.0	92.0	92.0	73.6
40	92.0	92.0	92.0	73.6
41	92.0	92.0	92.0	73.6
42	92.0	92.0	92.0	73.6
43	92.0	92.0	92.0	73.6
44	92.0	92.0	92.0	73.6
45	91.9	91.9	91.9	73.5
46	91.8	91.8	91.8	73.4
47	91.7	91.7	91.7	73.3
48	91.6	91.6	91.6	73.3
49	91.6	91.6	91.6	73.3
50	91.5	96.4	96.4	77.1
51	91.6	96.9	96.9	77.5
52	91.6	97.3	97.3	77.8
53	91.6	97.5	97.5	78.0
54	91.6	97.6	97.6	78.1

55	91.6	97.4	97.4	77.9
56	91.6	97.2	97.2	77.8
57	91.6	97.1	97.1	77.7
58	91.5	97.1	97.1	77.7
59	91.5	97.1	97.1	77.7
60	91.5	97.2	97.2	77.8
61	91.4	97.3	97.3	77.8
62	91.4	97.4	97.4	77.9
63	91.2	97.4	97.4	77.9
64	90.9	97.4	97.4	77.9
65	90.5	97.4	97.4	77.9
66	90.2	97.4	97.4	77.9
67	89.8	97.3	97.3	77.8
68	89.5	97.2	97.2	77.8
69	89.3	97.2	97.2	77.8
70	89.2	97.1	97.1	77.7
71	89.1	97.0	97.0	77.6
72	89.0	97.0	97.0	77.6
73	88.9	96.8	96.8	77.4
74	88.8	96.7	96.7	77.4
75	88.6	96.5	96.5	77.2
76	88.4	96.3	96.3	77.0
77	88.4	96.1	96.1	76.9
78	88.4	95.9	95.9	76.7
79	88.6	95.7	95.7	76.6
80	89.0	95.7	95.7	76.6
81	89.2	95.7	95.7	76.6
82	89.3	95.7	95.7	76.6
83	89.2	95.7	95.7	76.6
84	89.0	95.7	95.7	76.6
85+	88.7	95.7	95.7	76.6

Table 2: Summary measures from the three scenarios.

	Reproduction number	Cases (millions)	Deaths
Baseline	1.3 (1.1 - 1.6)	5.9 (5.7 - 6.3)	8,500 (7,500 – 9,100)
+ Booster	1.2 (1.0 - 1.5)	5.1 (4.9 - 5.4)	5,700 (5,200 – 6,300)
+ 12-to-15-year-old vaccination	1.1 (0.9 - 1.3)	3.6 (3.4 - 3.8)	3,500 (3,200 – 3,800)

Figure 2: The reproduction number as a function of percentage of active work and leisure contacts.

Figure 3: Total cases as a function of percentage of active work and leisure contacts.

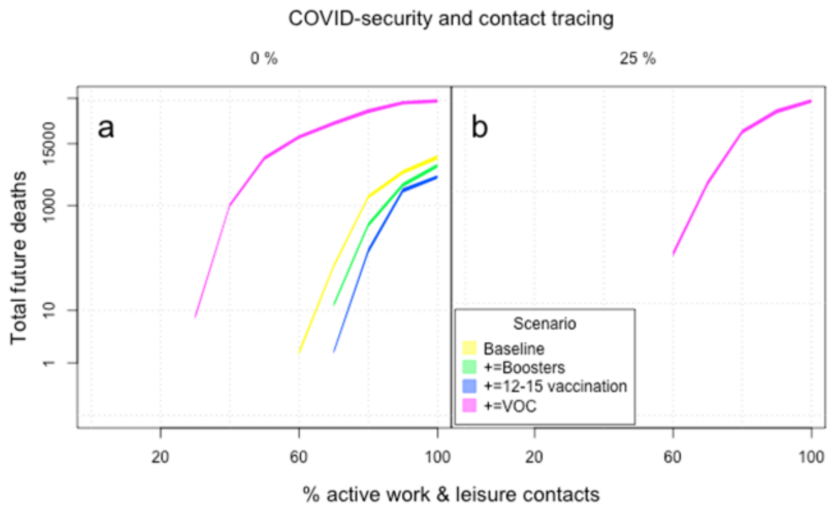

Figure 4: Total deaths as a function of percentage of active work and leisure contacts.

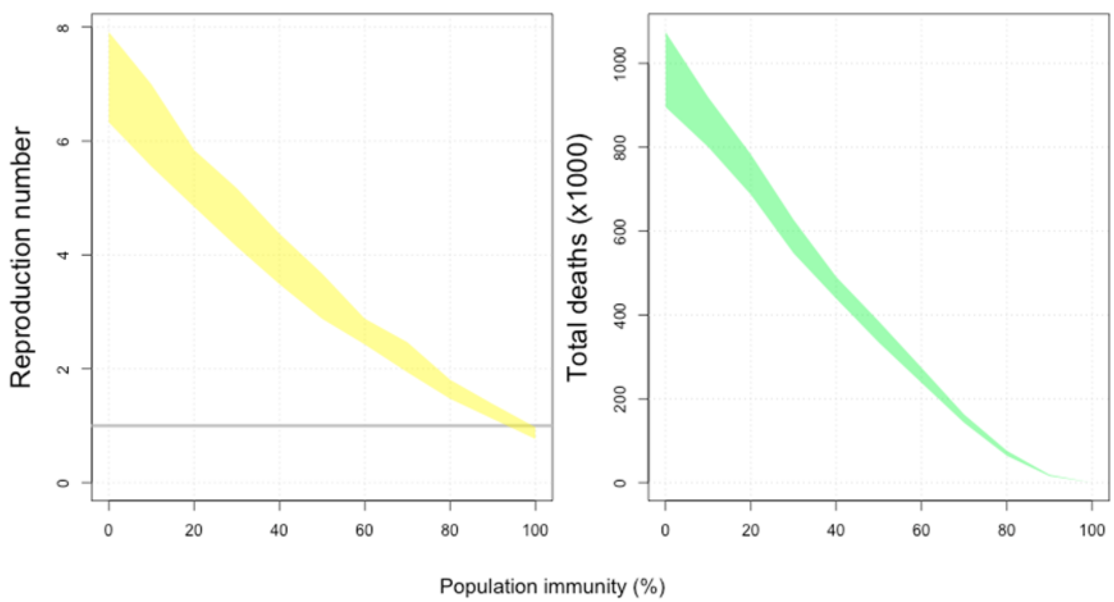

Figure 5: Reproduction number and total deaths as a function of percentage of the population with protective immunity.

References

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