HERD IMMUNITY – A PRIMER FOR POLICY MAKERS

[Redacted], University of Edinburgh, 04/01/21

1. 'Herd immunity' is generally taken to mean the proportion of the population that is immune to infection as a result of either natural exposure to infection or vaccination.

2. There is also a 'herd immunity threshold', where the proportion of the population that is immune is high enough for the incidence of new infections to go into decline. [Confusingly, when this threshold is reached the population may be described as 'having herd immunity', but it is entirely possible to have some level of herd immunity but not enough to pass the threshold – see Point 1].

3. A level of **herd immunity below the threshold can still be highly beneficial**, but – in the absence of other measures – will mean endemic infection in the long term.

4. The herd immunity threshold is related to the maximum value of the R number. The maximum value applies only during the early stages of an epidemic and in the absence of measures to suppress transmission.

5. For novel coronavirus, maximum R is around 3, which gives an approximate but useful estimate of the herd immunity threshold in the range 67%[1].

6. If the new variant increases transmissibility by 50% the threshold increases to 78%. A hypothetical new variant that was twice as transmissible would increase the threshold to 83% (note the diminishing impact of further increases in transmissibility).

7. As of January 2021, less than 10% of the Scottish population has had a novel coronavirus infection (extrapolated from seroprevalence data) so we are a long way from herd immunity (even if a single exposure gave 100% lifelong protection, which it may not – see below).

8. The contribution of a vaccine to herd immunity depends on how well the vaccine protects against infection. It also depends on how well it prevents those that do get infected from infecting others – this is called transmission blocking.

9. Note that herd immunity is <u>not</u> related (directly) to levels of disease, hospitalization and death. Whether or not the herd immunity threshold is reached depends only on the impact of natural exposure or vaccination on transmission.

10. Clinical trials of novel coronavirus vaccines only tell us about efficacy in preventing symptomatic infection.

11. The clinical trials do not tell us the efficacy in preventing severe disease. Hopefully this will be as high as the efficacy in preventing symptomatic infection – it could be higher.

[1] The formula is $1 - 1/R_{max}$

12. The clinical trials do not tell us the efficacy in preventing transmission. This is likely to depend on whether the vaccines prevent infection at all, or only suppress symptoms. We know from natural exposure that asymptomatic infections can be infectious (though significantly less so than symptomatic infections).

13. The clinical trials do not tell us how long vaccine-induced protection lasts. If it wanes significantly over a one-year period (allowing annual vaccination if necessary) this will make it much more difficult to reach the herd immunity threshold.

14. It will be some time (weeks or months) before we have reliable answers to Points 11, 12 and 13. Nor do we have this information for natural immunity. Until these issues have been resolved, **it is not possible to say with any confidence what the long-term impact of vaccination on the pandemic might be**.

15. The following compromise attainment of the herd immunity threshold through vaccination:
    a. Less than 100% reduction in infection/infectiousness (Point 12)
    b. Significant waning of protection between vaccinations (Point 13)
    c. Less than 100% coverage (90-95% may be the maximum feasible)
    d. More transmissible variants (see Point 6)
    e. Vaccine-escape variants

16. Given Point 15, **there is a realistic possibility that the herd immunity threshold for novel coronavirus cannot be reached by vaccination alone**.

17. At present, it would be risky to make policy solely on the assumption that we will reach the herd immunity threshold in Scotland in the foreseeable future.

18. Should the herd immunity threshold be reached this does not mean that transmission will cease, only that the R number (in the absence of any other measures) would fall to 1. If the prevalence is still high, e.g. similar to current levels, there would still be a long epidemic tail.

19. Herd immunity through vaccination should significantly reduce the R number even if the threshold is not reached. That may mean that some measures can be lifted without allowing the epidemic to increase again.

20. The herd immunity threshold can be lowered by reducing transmissibility, e.g. through *permanent* implementation of selected NPIs. This may bring it within reach. If the maximum R value was reduced to, say, 2 then the herd immunity threshold would fall to 50%.

21. Vaccination should greatly reduce the fraction of infections causing severe disease or death regardless of whether the herd immunity threshold is reached. But the absolute number could still increase in the short-term if the epidemic grew too large.

22. At best, the medium-term outlook (winter 2021-22 and possibly beyond) is likely to involve a residual level of COVID-19 and quite possibly regular large outbreaks. **There will be a balance to be struck between the relaxation of measures and the COVID-19 burden**.