August 20, 2021

The Independent Scientific Advisory Group for Emergencies (SAGE)

The Independent SAGE Report 47

(How) can we reach herd immunity?

www.independentSAGE.org
@independentSAGE
YouTube: IndependentSAGE

Submitted to The UK Government and the People of Great Britain & Northern Ireland by Sir David King, former Chief Scientific Adviser, UK Government, Chair of Independent SAGE

(How) can we reach herd immunity?

The term 'herd immunity' first found its way into the UK's public consciousness very early on in the pandemic. In early March 2020, the UK's Chief Scientific Officer, Sir Patrick Vallance, talked about allowing "enough of us who are going to get mild illness to become immune" and building up "some degree of herd immunity whilst protecting the most vulnerable"[i]. What he meant was that the more people that got the infection, the fewer susceptible people would be left to catch it in the future. As there are fewer and fewer people who remain uninfected, the virus will find it more and more difficult to find new people to infect. Eventually the virus is unable to sustain a trail of infection and it disappears.

Whilst this is a reasonable approach for an infection which is universally asymptomatic or, at most, causes only trivial symptoms, for an infection such as COVID19, this is dangerous.

Without a vaccine the only way to achieve herd immunity is for a huge number of people to become infected – with the attendant illness and death that accompany these natural infections. The idea was greeted with substantial concern from broad swathes of the scientific community[ii] and talk of herd immunity as a strategy was subsequently quashed by the government and its existence as an active policy denied.

Despite the toxic connotations the phrase took on for many, herd immunity is an incredibly important concept. It suggests diseases can be eliminated without everyone being immune. To achieve it, people can gain immunity in two different ways: through being infected and recovering or through being vaccinated. For covid, the best way for people to get immunity is through vaccination[iii], even for younger age groups who are at a lower risk from severe complications due to covid[iv].

When enough people have immunity to the currently circulating variant, the number of new cases will start to decline. But how many people need to have immunity before the disease starts to die out? To calculate the so-called 'herd immunity threshold' (HIT) we need to do some mathematical epidemiology.

At the beginning of an epidemic when almost everyone is susceptible to the disease and there are no interventions in place to control it, simplistically speaking, the disease dynamics can be boiled down to a single number, R_0 – the basic reproduction number. This tells us how many people we expect each infected person to pass the disease onto over the course of their infectious period. This is a special case of the *R*-number we have become so familiar with from the news – the zero-subscript indicating this is the value of *R* at the *beginning* of an epidemic with *zero* interventions in place and before people alter their personal and collective behaviour.

If we can reduce *R* so that it is below 1, then the disease will begin to decline. One way to do that is for people to gain immunity. The more people that have immunity the fewer people each individual will be able to pass the disease onto. If p is the proportion of the population that is immune (and $(1-p)$, therefore, the proportion not immune) then we can calculate the current reproduction number from the basic reproduction number as $R=R_0*(1-p)$. If a proportion $p=1-1/R_0$ of people are immune then this takes us to R=1, the tipping point at which infection should start to decline. If, for example, the original covid variants circulating in the early stages of the pandemic had an R_0 of 3 then at least two-thirds of the population would need to have perfect immunity to bring *R* below 1. With more transmissible variants[v] such as delta, which may have a basic reproduction number as high as 6[vi], this calculation suggests that the HIT might be as high as 83%.

This is a very simplistic picture, but it can be useful for back of the envelope calculations. In reality many factors will influence the HIT. One consideration is the degree of immunity conferred. The type of immunity we are interested in to achieve herd immunity is *immunity from catching and passing on the disease* (i.e. transmission). Vaccines, for example, are not 100% effective at stopping people from transmitting the virus. Immunity from natural infection is thought to be even less effective than that from vaccines. This means the HIT will be higher than suggested by the simplistic calculation above. Even if vaccination reduced the degree of onwards transmission by as much as 85%, this would mean you would need to have vaccinated 98% of the population to achieve the required reduction in transmission. The potential for immunity to wane also means we would need to think about delivering regular booster vaccinations. Variants such as Delta, which reduce the ability of vaccines to prevent transmission even while maintaining protection against severe disease, make herd immunity much harder to reach.

Another important factor is how evenly immunity is spread among the population. Human populations do not mix with everyone else equally. Different sub-populations also have different behavioural traits and varying attitudes to vaccination and preventive measures. These issues are particularly important factors when we are vaccinating by age cohorts. Immunity will not be spread evenly. Even if we exceed a theoretical herd immunity threshold through vaccination averaged over the entire population, if there are regions or communities that have not reached that threshold, then the disease can still spread freely in these groups. By deciding not to offer the vaccine to children, for example, we are providing a large reservoir of unprotected people in which the virus can freely circulate. In the UK around 21% of the population are, under present policies, too young to be vaccinated.

Conceptualising a population's level of immunity as "all or nothing" is not particularly helpful - so we shouldn't get too hung up on whether we've reached a theoretical threshold or not. It creates the false impression that there is a fixed target that – if reached – will immediately suppress viral transmission. This is wrong on two counts: first, the herd immunity threshold fluctuates with the seasons (generally in winter we need more people to be immune) and viral transmissibility (e.g., new variants can change the game); second, bringing *R* to just below one will still allow significant numbers of infections to occur as the disease dies out - the lower we can make *R* the fewer infections we will incur as the disease declines.

Generally as immunity builds up in the population it slows the spread. Even if we can't reach a level of immunity that will keep *R* below one once all restrictions are relaxed (and certainly without vaccinating children it is unlikely we can reach the levels required without significant infection-mediated immunity and its attendant consequences), the more population-level immunity we have the slower the spread will be and the easier it will become to control covid though tried and tested public health measures. But it is worth noting that unless you have effective public health control measures in place the infection can return and flare up. For example, in 2016 the UK lost its status as a country that eliminated measles because the virus was again spreading in communities.

It is also possible that we will not be able to reach the herd immunity threshold with Delta (or subsequent variants) without new vaccines or millions more people infected, because current vaccines are not sufficiently effective at preventing transmission (data from Israel suggests that Pfizer for instance is only 64% effective at preventing infection).

The relaxation of almost all restrictions from 19 July has made it clear that the government and its advisors believe that the UK's path towards herd immunity will, at least in part, be through natural infection, with all the consequences that entails. Recent spread has already seen healthcare services struggle to cope[vii] under excess pressure and will lead to many avoidable deaths and long-term illnesses. Currently, around 45% of the UK population are not yet fully vaccinated. Denying everyone in the country the best chance of being protected through vaccination and relying instead on "caution, vigilance and personal responsibility" to tackle an airborne and highly contagious infectious disease is an abdication of responsibility, which will involve exposing millions to the acute and long-term impacts of mass infection.

---

[i] Retrieved from: https://www.bbc.co.uk/news/uk-politics-54252272

[ii] Retrieved from: http://maths.qmul.ac.uk/~vnicosia/UK_scientists_statement_on_coronavirus_measures.pdf

[iii] Retrieved from: https://directorsblog.nih.gov/2021/06/22/how-immunity-generated-from-covid-19-vaccines-differs-from-an-infection/

[iv] Retrieved from: https://sciencebasedmedicine.org/covid-19-and-balancing-the-risks-the-vaccine-or-the-virus/

[v] Davies, Nicholas G., Sam Abbott, Rosanna C. Barnard, Christopher I. Jarvis, Adam J. Kucharski, James D. Munday, Carl AB Pearson et al. "Estimated transmissibility and impact of SARS-CoV-2 lineage B.1.1.7 in England." *Science* 372, no. 6538 (2021). https://science.sciencemag.org/content/372/6538/eabg3055

[vi] Callaway, Ewen. "Delta coronavirus variant: scientists brace for impact." *Nature*. https://www.nature.com/articles/d41586-021-01696-3

[vii] Retrieved from: https://www.theguardian.com/world/2021/jul/08/nhs-hospitals-forced-to-cancel-operations-again-by-unfolding-third-wave

indie_SAGE