14. Epidemiology

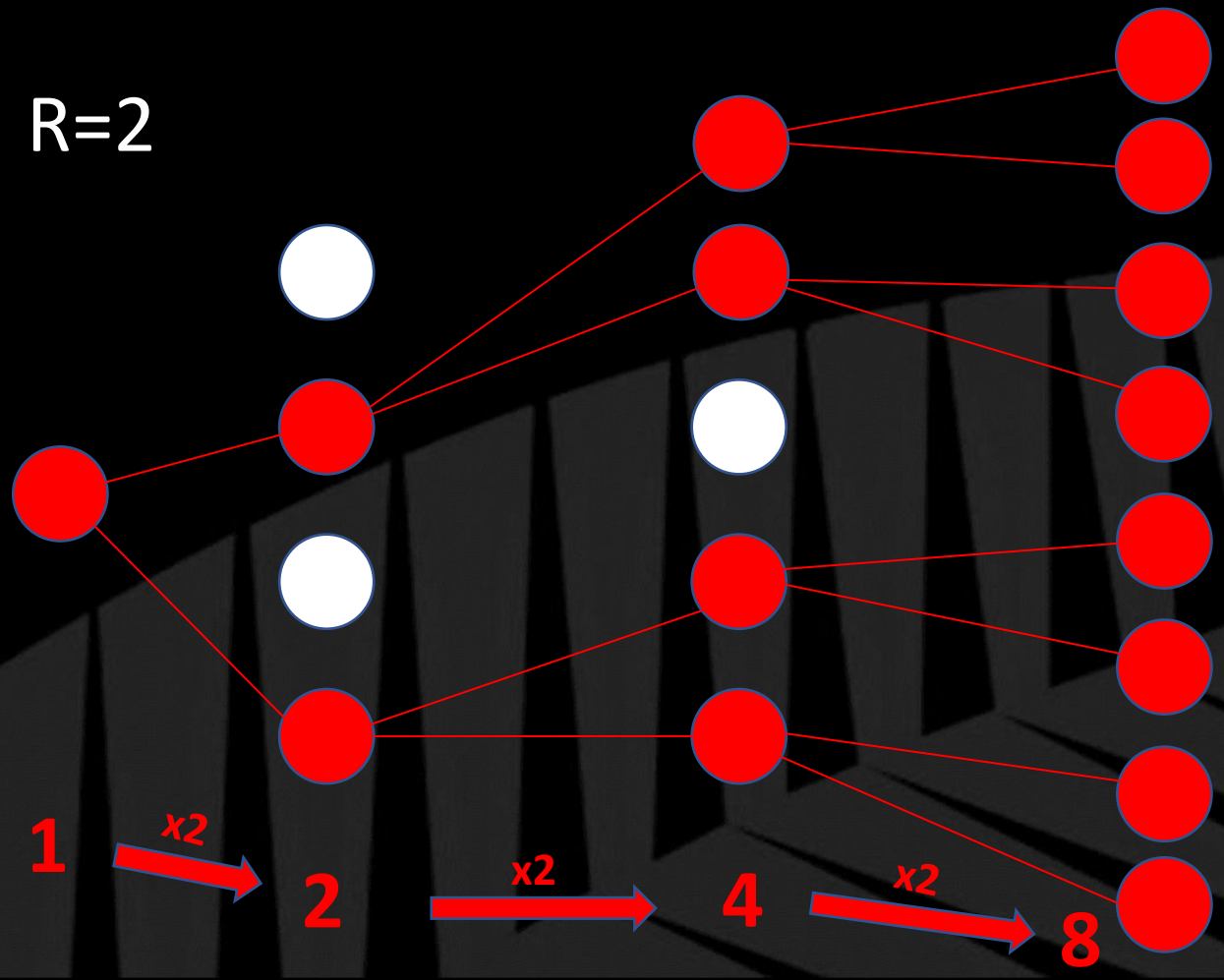
Sumner Hancock

14. Epidemiology

- Is it possible to reach herd immunity through vaccination?

The Reproductive Number

- Average number of new people an infected person will infect



The Reproductive Number

R_0

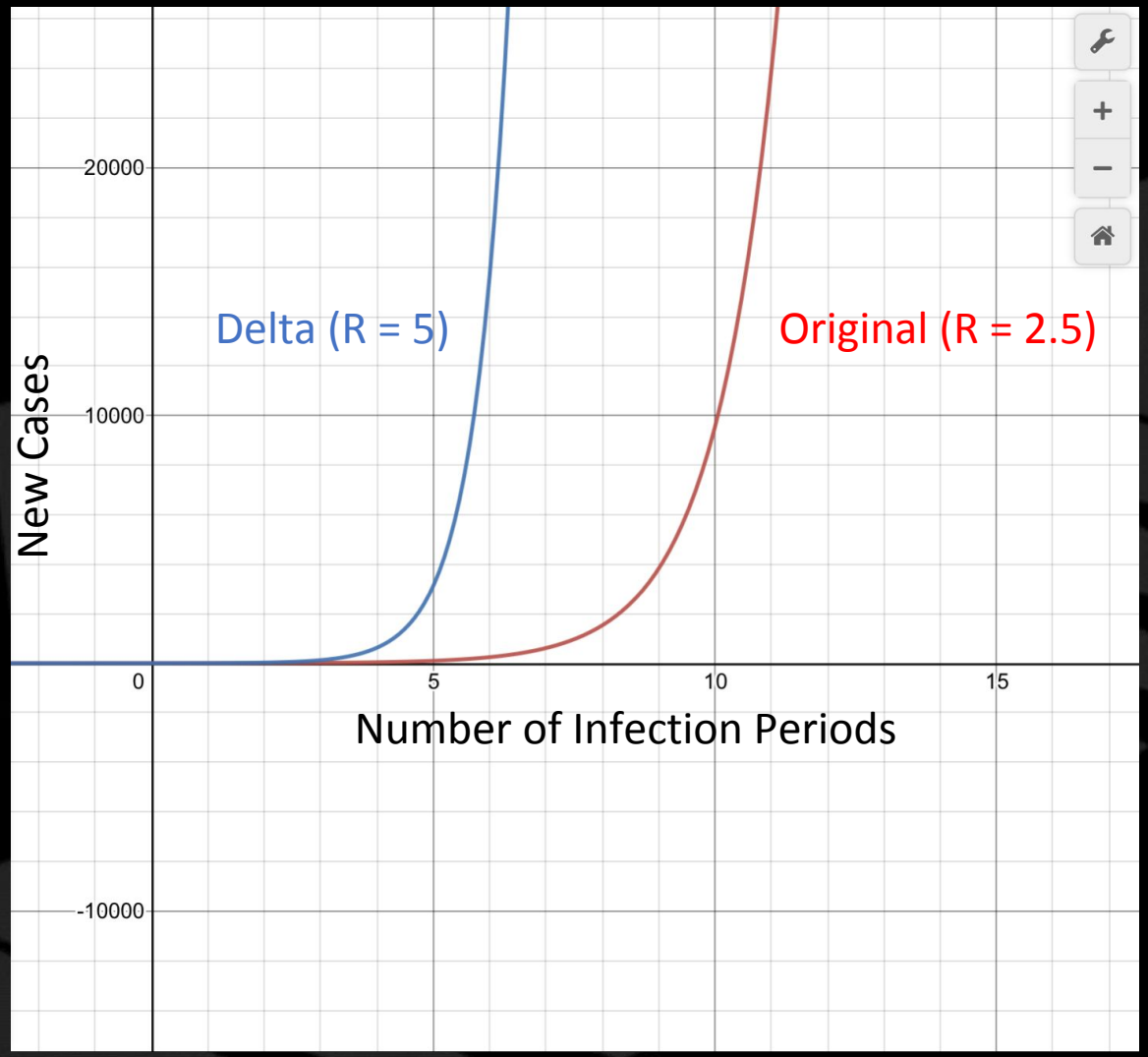
- With no precautions
- Original Covid-19 $R_0 = 2.5$
- Delta variant $R_0 = 5\text{-}6$

R_e

- With Precautions (quarantine, vaccines, masks)

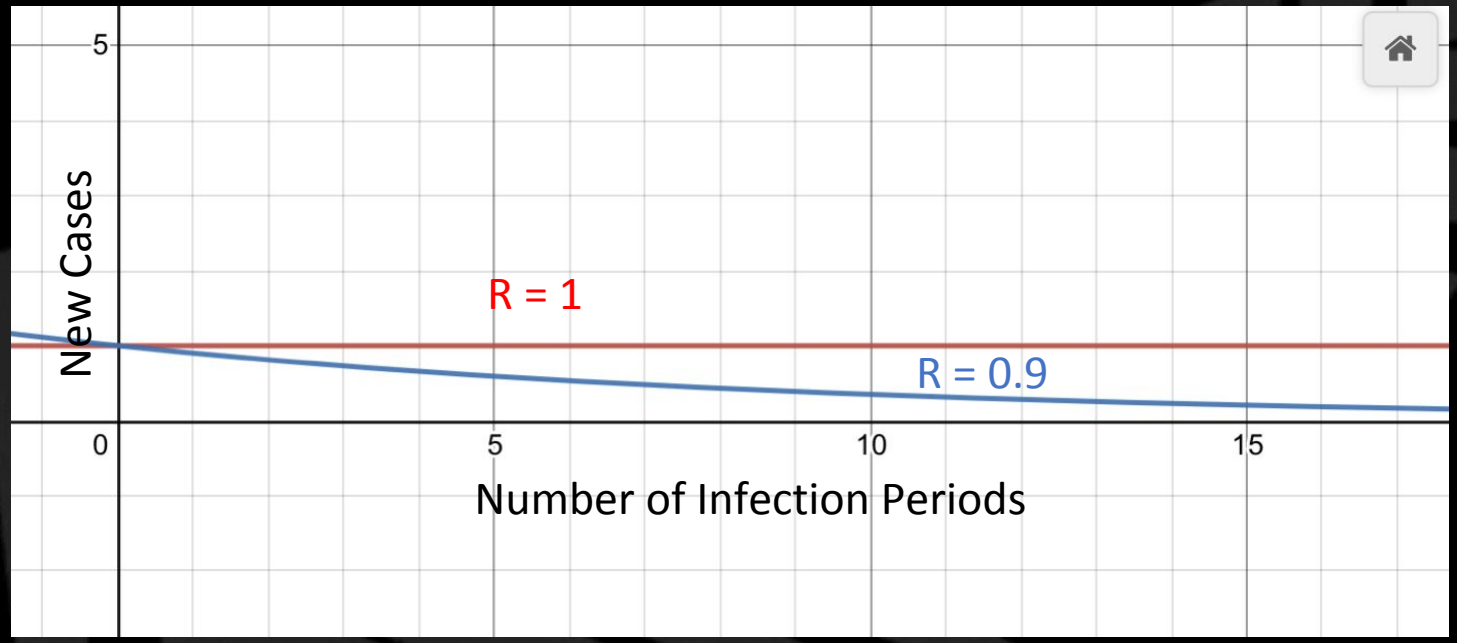
Infection rates = R^x

- Greater R number causes the rate of infection to increase by a lot



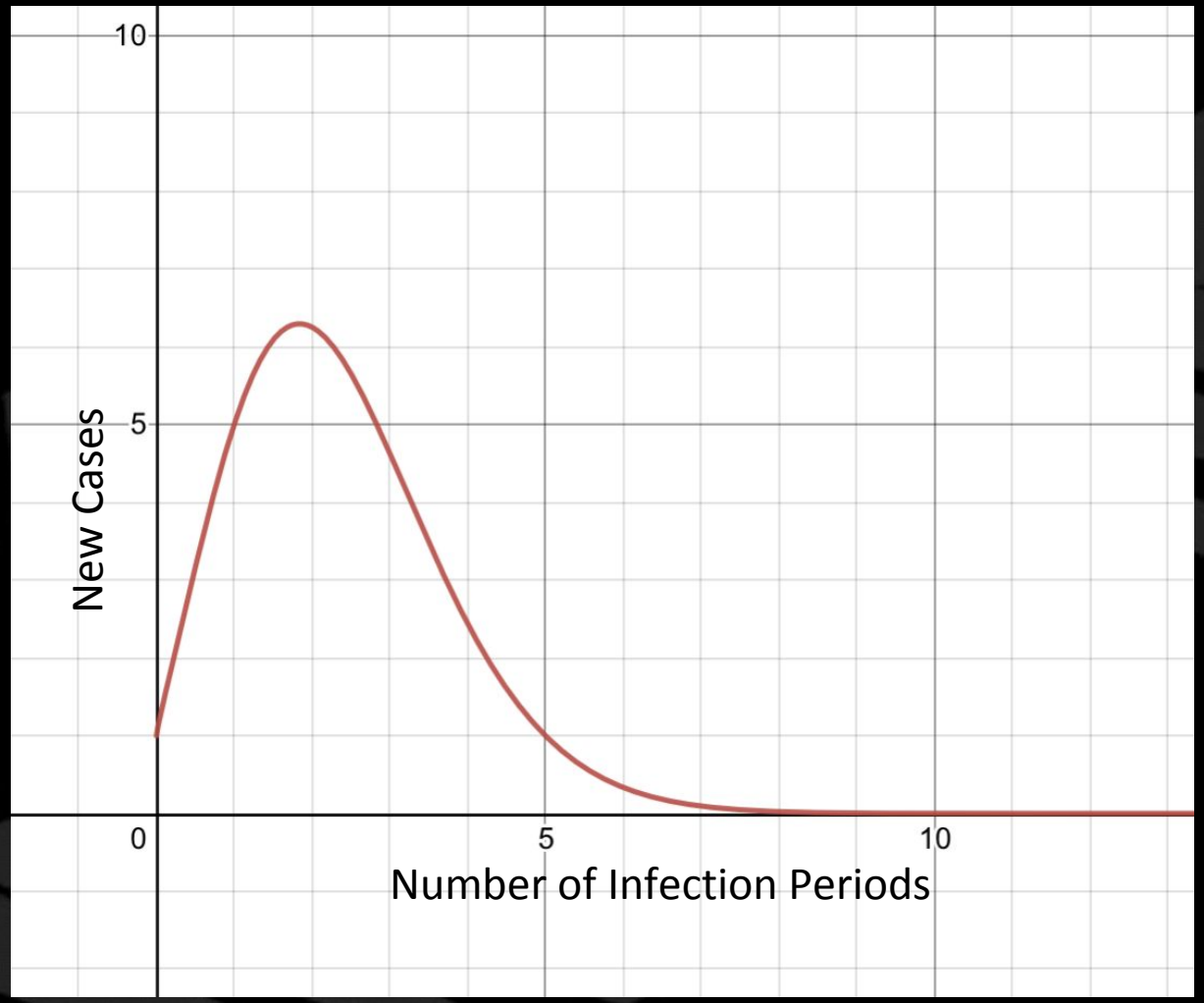
Infection rates = R^x

- R = 1 causes stagnation
- R < 1 causes a decay curve with decrease
- We are aiming for R < 1



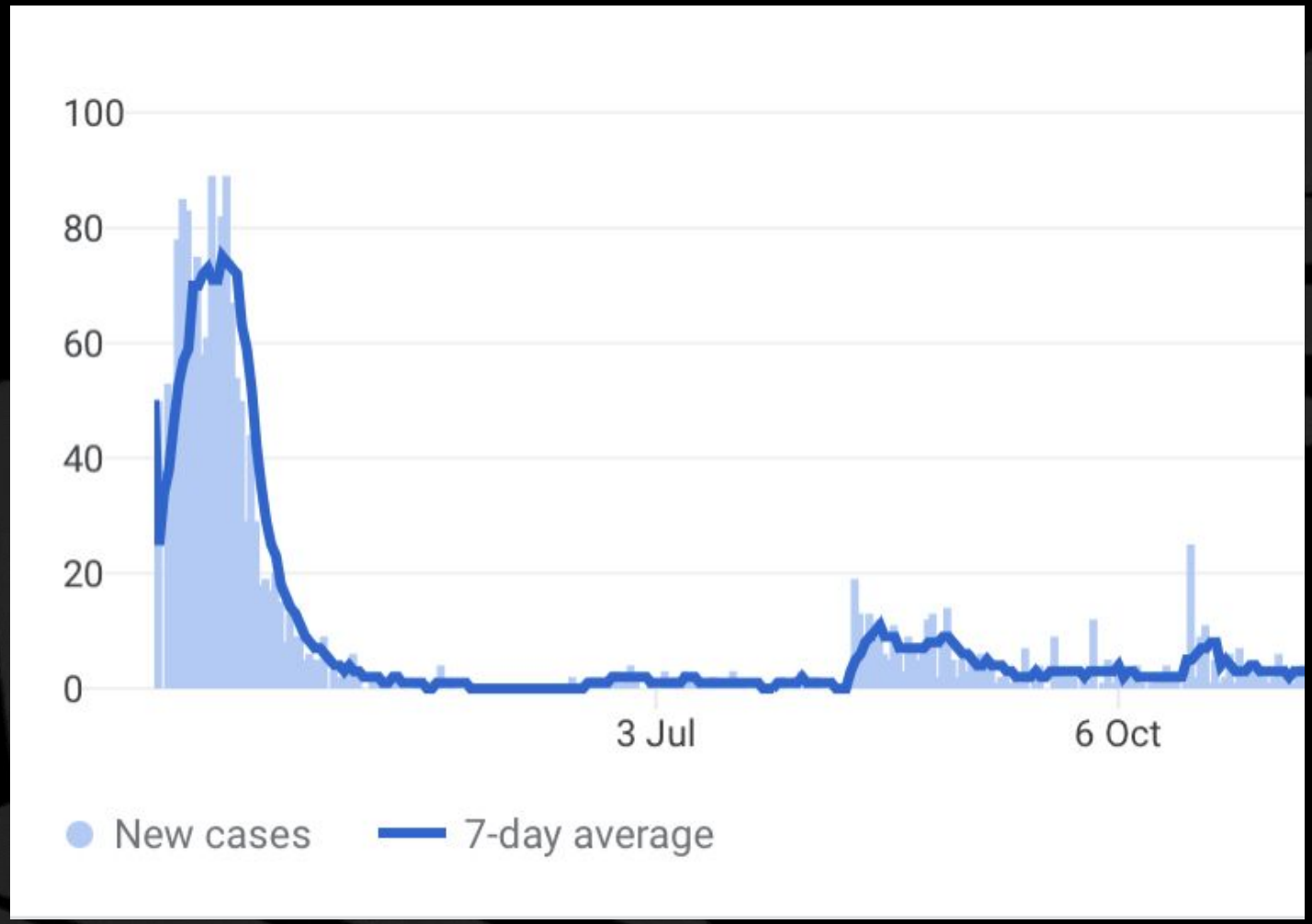
Infection rates = R^x

- Goal to where the R starts high but is quickly decreased to near 0



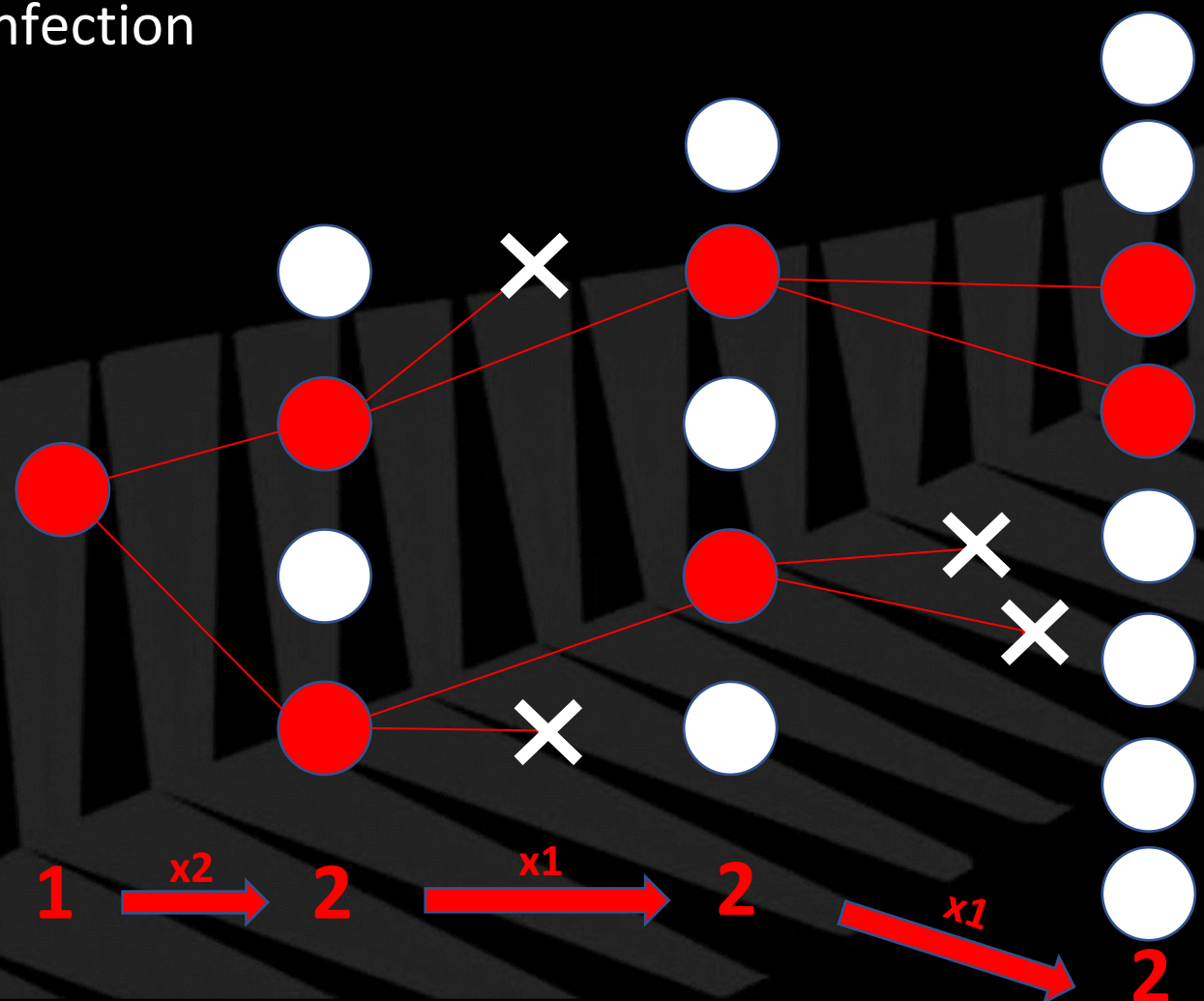
Reality

- Similar to predicted graphs
- Variance due to R number being an average not a definite
- R number fluctuates as lockdowns happen and masks are worn



How to decrease the R number

- We decrease the R number by blocking points where infection can occur



Herd Immunity Threshold

- HIT is the percentage of people that need to be immune for R = 1
- We are aiming to hit the HIT through processes such as vaccinations and masks

$$Herd\ immunity = 1 - \frac{1}{R_0}$$

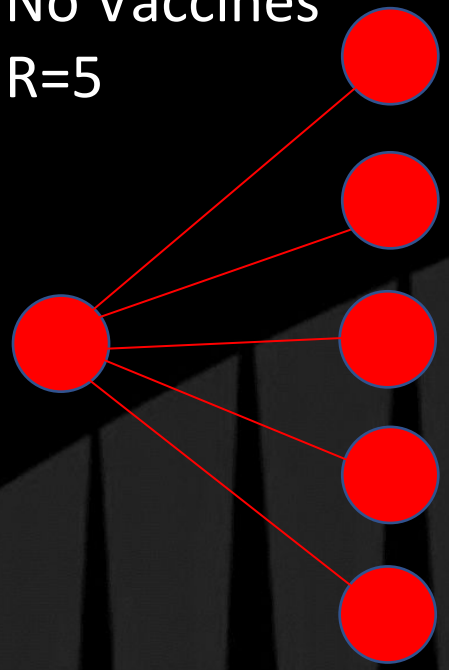
Herd Immunity Threshold

- For the Delta variant, which is most common, the HIT is 80% (using $R_0 = 5$)

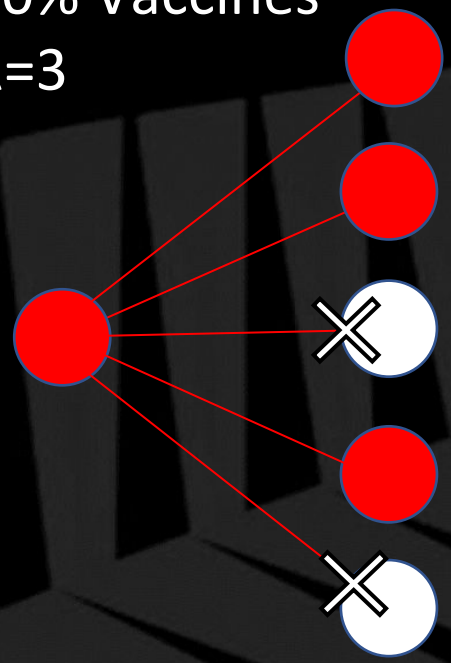
Vaccines

- Assuming vaccines grant immunity

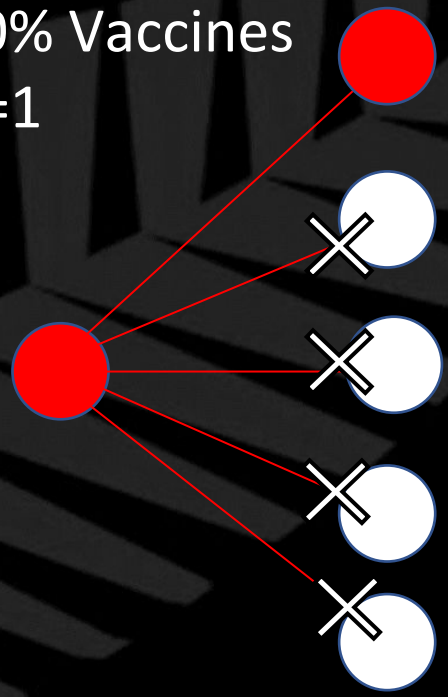
No Vaccines
R=5



40% Vaccines
R=3



80% Vaccines
R=1



Vaccines

- Unfortunately, vaccines do not grant Immunity
- Pfizer vaccine only 80% effective at stopping you from getting the virus
- Those with Pfizer 50% less likely to spread

Full Immunity | Vaccine Effectiveness | Less Spread

$$1 \times 0.2 \times 0.5 = 0.1$$

10% of vaccinated not immune

Vaccines

- What percentage of the population do we need vaccinated for herd immunity?

Vaccinated percentage

$$v \times 0.9 = 0.8$$

HIT

Effective Immunity from Vaccine

$$v = 0.\dot{8}$$

$$\approx 0.9$$

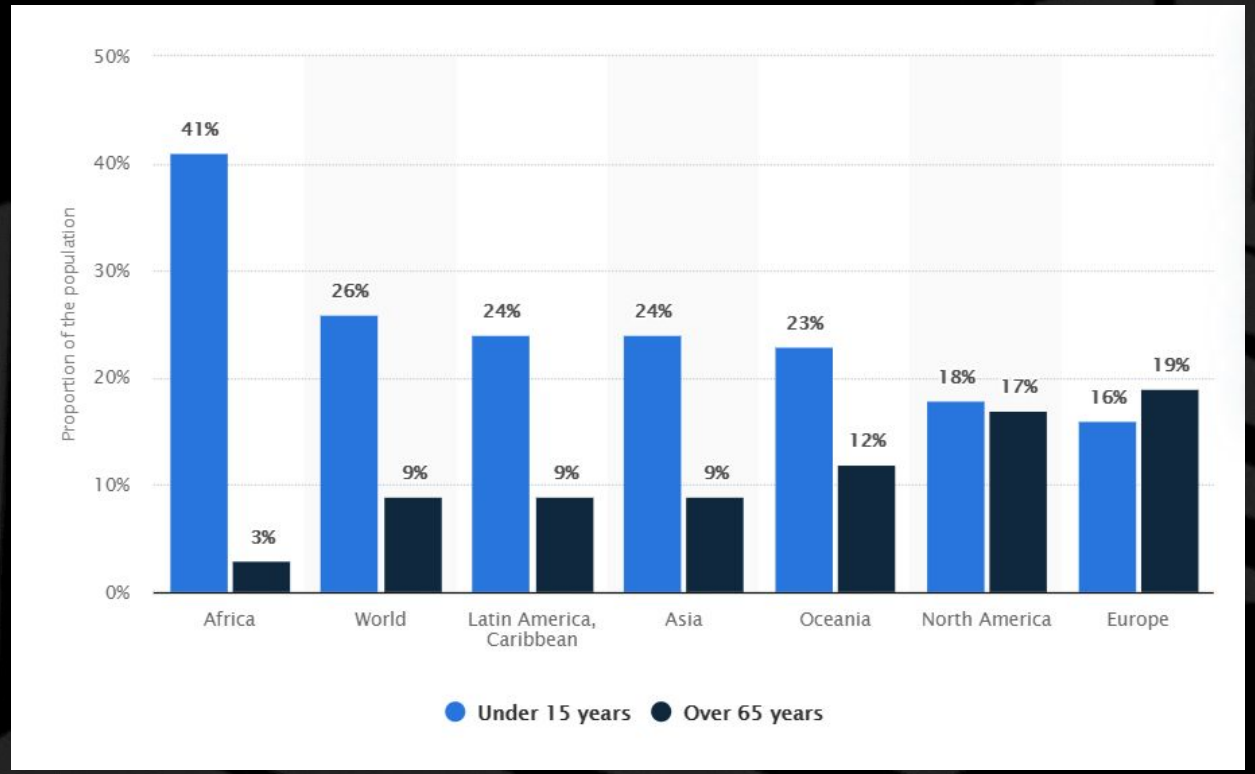
Rounded up because we want R < 1

Can we vaccinate 90%?

- 90% is a very high bar, we can only afford 10% not to be vaccinated
- We would have to vaccinate elderly and Children
- Current vaccine hesitancy is high

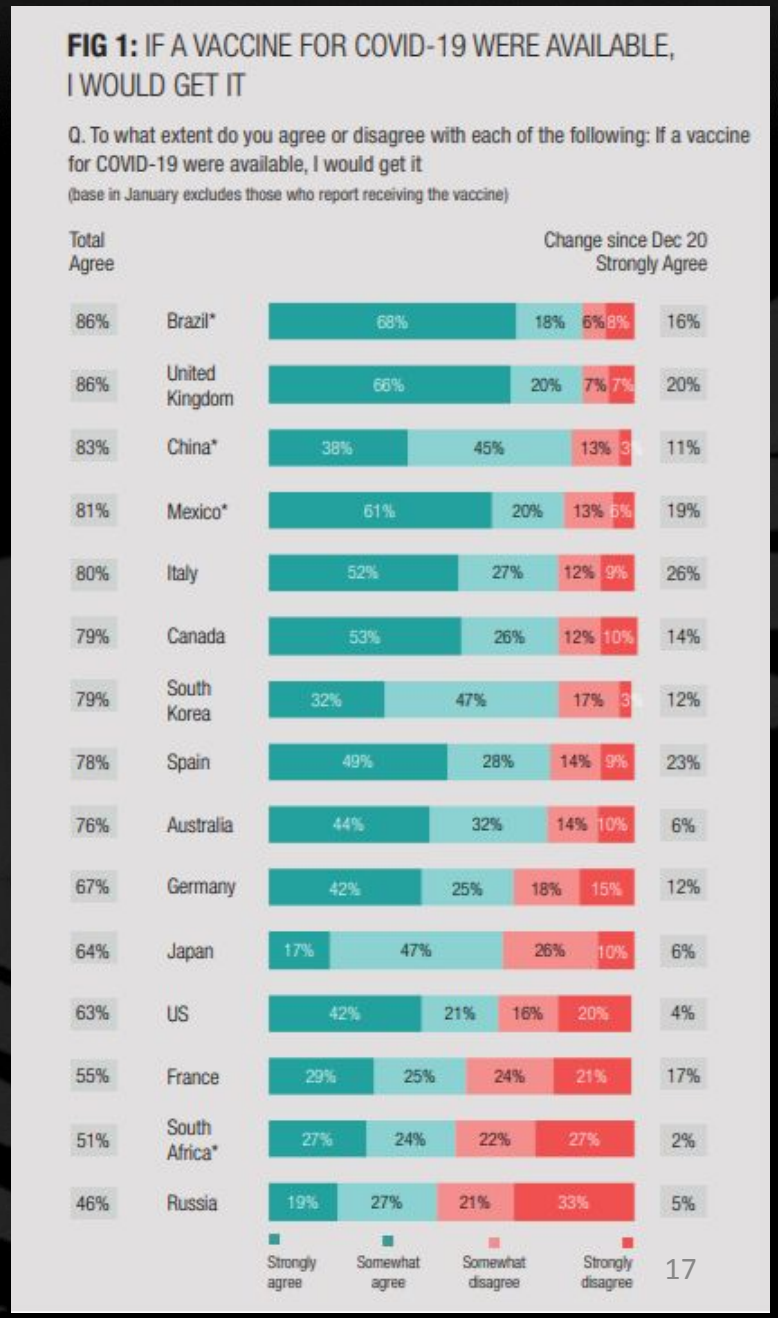
Children

- Vaccinating those under 16 is currently contentious, but to achieve herd immunity we must
- For NZ every single person above the age of 9 must be vaccinated



Hesitancy

- A significant portion of people don't want to be vaccinated
- To reach herd immunity we would need compulsory vaccination

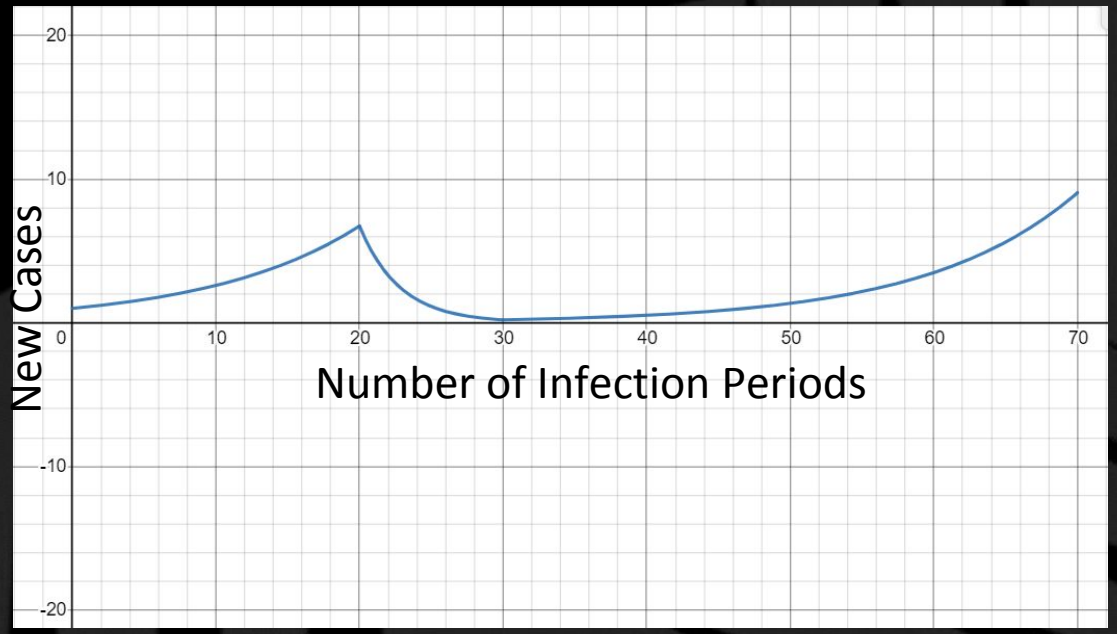


Alternatives

- Compulsory vaccination for everyone above 9 is unrealistic (this is even ignoring people who can't take the vaccine for medical reasons)
- We can either:
- Have periodic lockdowns
- Never go back to "normal"

Periodic Lockdowns

- For the UK during lockdown 0.7<R<0.9 (I'll take lower limit assuming that a large portion of the population is vaccinated)
- We could live normal lives but then lockdown every once in a while when Covid-19 rates are too high



No “Normal”

- Never open borders
- Keep wearing masks in public
- Contact Tracing
- Quarantines

Conclusion

- To stop the pandemic, we need to decrease the R number
- Vaccines alone aren’t capable of stopping the virus
- We might never go back to a pre-Covid world

Sources

- https://www.statista.com/statistics/265759/world-population-by-age-and-region/
- https://www.occ.org.nz/assets/Uploads/StatsOnKids/demographics2016.pdf
- https://assets.ipsos-mori.com/worldeconomicforum/Ipsos_vaccine_paper_Jan2021.pdf
- Tony Blakely
- https://academic.oup.com/jtm/advance-article/doi/10.1093/jtm/taab124/6346388