MATTERS ARISING

On the immunization criterion for Covid-19

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The immunization criterion is important in dealing with epidemics and pandemics because if it is met, the infection cannot increase. In the section "Modeling" of my paper,[1] the immunization criterion was given as (eqn 5):

$$\rho/\beta \geq 1,$$

where ρ is the rate coefficient for recovery in the SIR model and β is the rate coefficient for infection; i.e., a measure of contagiousness. Strictly speaking, the right hand side of the inequality should be the susceptible fraction s, i.e.

$$\rho/\beta \geq s.$$

Of course at the very beginning it is supposed that s does equal unity, but in reality it cannot, for then the infected fraction i would be zero and there would be no epidemic (ds/dt in eqn (1)[1] would be zero); moreover the cancellation of i in eqn (2)[1] would not be legitimate. The condition for population immunity (also sometimes called group or herd immunity) is based on the assumption that all those who are not susceptible, i.e. the fraction $1 - s$, are immune, therefore the condition can be written

$$1 - s \geq 1 - \rho/\beta = 1 - 1/R_0$$

making use of the definition of the reproduction number R_0 (eqn 6[1]). If the disease is highly contagious (large β), then nearly everyone in the population will have to be immune to achieve group immunity. ρ/β was estimated as 1/3 early on,[1] which still seems to be a reasonable estimate; it implies that about 67% of the population would have to acquire immunity, either naturally through contracting the disease or with a vaccine, to achieve group immunity. But β can be diminished by physical distancing (often called social distancing) of people from each other—this was previously estimated to lower ρ/β to 0.1 under conditions of strict lockdown,[1] which would enable group immunity to be achieved even if hardly anyone had acquired individual immunity. Tripling the recovery rate (which, from the present perspective, means the

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[1] J.J. Ramsden, COVID-19. *Nanotechnol. Perceptions* **16** (2020) 5–15.

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rate at which infected people cease being contagious), represented by ρ, would have a similar effect to that of strict lockdown, but this has not been the focus of public health efforts.[2]

Because of the considerable health risks, both short- and long-term, from contracting Covid-19, vaccination is considered to be the preferred method to acquire immunity. There are, however, severe logistic and financial obstacles to vaccinating the majority of the population. In practice one may be able to achieve vaccinating half the population. The immunization criterion would then be fulfilled with mild physical distancing sufficient to reduce β from its initially estimated value by a third. Hopefully such a regimen would result in little economic disruption. It seems clear that the death toll from severe economic disruption could easily exceed the worst mortality estimates from the virus spreading unchecked,[3] the detailed reasons for which include loss of income leading to malnutrition and missed hospital appointments for surgery and other treatment unrelated to Covid-19. Hence, there is a strong motivation to minimize economic disruption. It is not, however, encouraging that there appears to be little attempt to link the precise rules regulating citizens' behaviour to the parameters of the epidemiological model, let alone any economic model, by those responsible for formulating and enforcing the rules.

[2] The requirement for people infected with SARS-CoV-2 to place themselves in quarantine for 14 days (also called self-isolation) could be seen as an intervention on ρ rather than β.

[3] P.Thomas, J-value assessment of how best to combat COVID-19. *Nanotechnol. Perceptions* **16** (2020) 16–40.