Mitigation of COVID-19 epidemics will likely fail if the population reduces rates of transmission in response to the saturation of critical care facilities

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The UK is currently planning a mitigation response to the COVID-19 epidemic rather than ongoing containment. This strategy is informed by prior modelling studies and analysis of the severe 1918 influenza pandemic. The primary benefit of mitigation is that the epidemic will be over more quickly than might otherwise be the case, with the population having acquired herd immunity and also having experienced a relatively low peak. Here, we use simple compartmental models and recent infection fatality rate estimates for the UK to explicitly examine the implications of the UK population responding to a severe pathogen more strongly than did populations in 1918. We show that critical care facilities in the UK would be saturated quickly. If populations spontaneously reduce transmission close to threshold values when this occurs, any possible benefits of attempting mitigation are lost. The country would then have to either struggle on to the availability of a vaccine without a functioning health system or attempt the most stringent possible interventions to lower incidence back to containment levels. Over the same period of time, either of these scenarios would likely have far greater economic costs than would result from an immediate switch now to ongoing containment. These results directly support current advice from the World Health Organisation and are consistent with policy decisions made by China, Hong Kong, Singapore, Japan, South Korea and most recently Italy. Even if ongoing containment were to fail, we would have gained time and knowledge with which to decide our next strategy.

At the end of December 2019, cases COVID-19 severe respiratory disease, caused by the SARS-CoV-2 virus were reported to the World Health Organization [1]. Since then, the virus has spread to all global regions and is in the process of taking off in many countries. Many vaccine candidates are under development, but reliable products are not expected to be available in large volumes for 18 months, and there are no guarantees that vaccines will be available then [2].

Government responses to the global spread of COVID-19 fall into two broad categories: either countries are attempting to minimize the number of cases by keeping transmission below the critical threshold (ongoing containment, e.g. China, Hong Kong and Singapore) or intervention plans are in place to dampen transmission such that populations achieve no more than the required herd immunity with as little societal disruption as possible (mitigation, e.g. UK and USA).

Government policy during a pandemic is not determined only by epidemiology. In theory, any epidemic of a directly transmitted pathogen can be stopped if all social contact is stopped, as was the case in China initially. However, without any activity the economy also halts, resulting in societal breakdown and associated adverse health outcomes. Although the complete shutdown of Wuhan in China was sufficient, it may not have been necessary to achieve ongoing control of COVID-19. China's stated aim is to restart the economy and to

Figure 2, Table 1). A behaviour change smaller than a drop in R_0 1.3 to 1.1 from a period of effective mitigation with critical care to a period without critical care seems unlikely.

Discussion

If the local human population responds to saturation of critical care with COVID-19 patients by reducing contacts such that transmission is close to R=1, there will be no benefit to attempting mitigation over attempting ongoing control. Rather, the epidemic will still last through to the time at which a vaccine may be available, far more people will be infected than would be the case with ongoing containment, and far more will die. The health care service will never have an opportunity to recover and it seems likely there would be substantial additional health costs from the knock-on effects of the prolonged period of high COVID-19 incidence.

Our study has a number of limitations. The model is not spatial nor age structured. Rather it is as simple as possible to make the key points. The scale of difference between the health benefits is so large that we do not think this is an issue. However, we have not directly strong age specific social distancing with the other policies. Because the fatality rate is so much higher in older age groups, it is possible that a very stringent social distancing of older adults could dramatically reduce the crude numbers of deaths presented here based on age-averaged values. That said, IFR values are close to 1% even in the 50-59 age group, so it is not immediately clear how such a strategy could be implemented in an even approximately equitable way.

Essentially, our choice is whether to live with relatively high levels of infections and to let the virus decide our social structure for the next 18 months, or for us to find a way to live such that we keep levels of infection low and our social structures as close to normal as possible.

These results could be disheartening to those planning a response to COVID-19 epidemics. However, we suggest that they may also be a powerful positive motivation for action. The model results here do no more than reinforce the findings of the WHO China Mission and validate the strategy adopted by Chinese health authorities in or around the 23rd of January 2020; and then subsequently by Hong Kong, Singapore, Japan, and South Korea. We suggest that they are strong evidence with which to abandon mitigation strategies, justified in any way by the possibility of a short epidemic. Governments need to devote the entirety of their attention and resources to creating viable ongoing solutions to the presence of this virus. We suggest that the first step is to adopt stringent fixed-term social distancing so as to give time for detailed planning the rapid development of any accompanying technology.

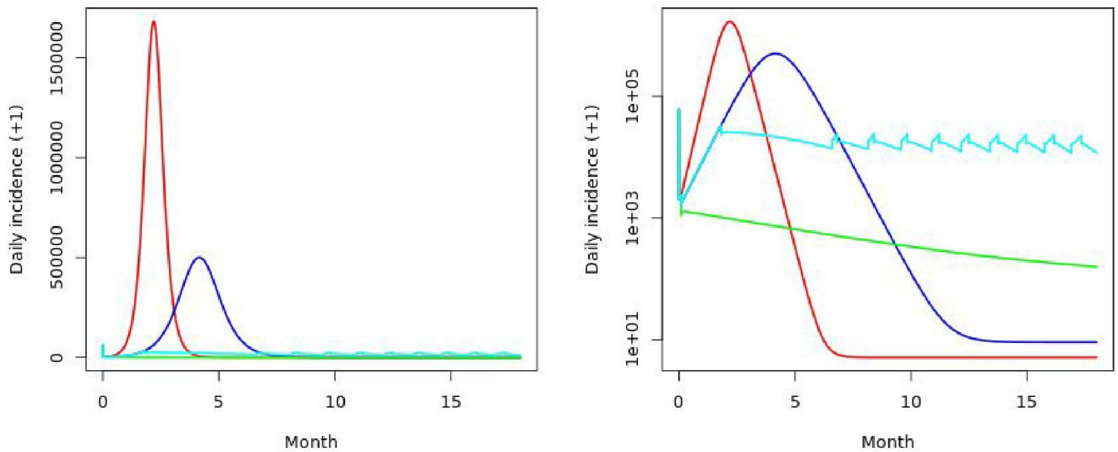

Figure 1. Epidemic trajectories on a linear (**A**) and log (**B**) scale for alternate response strategies. Red is an unmitigated epidemic (UE) with R_0=2.0. Blue is a "successfully" mitigated (SM) epidemic with a later lower peak that still achieves herd immunity for the unmitigated R_0 (however, the negative population health implications of SM are still enormous). Green is the ideal solution of successful sustained ongoing containment (SC). Cyan represents "unsuccessful" mitigation, which has far less negative impact on the population than SC, but lasts for the full 18 months and does not generate herd immunity. See Supporting Information R script and www.github.com/c97sr/idd.