Epidemiology of COVID-19

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March 25, 2020

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

March 16, 2020

Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand

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COVID-19 is a major world health threat… What are the strategies?

(a) **Suppression.** Here the aim is to reduce the reproduction number (the average number of secondary cases each case generates), R, to below 1 and hence to reduce case numbers to low levels or (as for SARS or Ebola) eliminate human-to-human transmission. The main challenge of this approach is that NPIs (and drugs, if available) need to be maintained – at least intermittently - for as long as the virus is circulating in the human population, or until a vaccine becomes available. In the case of COVID-19, it will be at least a 12-18 months before a vaccine is available[3]. Furthermore, there is no guarantee that initial vaccines will have high efficacy.

(b) **Mitigation.** Here the aim is to use NPIs (and vaccines or drugs, if available) not to interrupt transmission completely, but to reduce the health impact of an epidemic, akin to the strategy adopted by some US cities in 1918, and by the world more generally in the 1957, 1968 and 2009 influenza pandemics. In the 2009 pandemic, for instance, early supplies of vaccine were targeted at individuals with pre-existing medical conditions which put them at risk of more severe disease[4]. In this scenario, population immunity builds up through the epidemic, leading to an eventual rapid decline in case numbers and transmission dropping to low levels.

Methods

Transmission Model

We modified an individual-based simulation model developed to support pandemic influenza planning[5,6] to explore scenarios for COVID-19 in GB. The basic structure of the model remains as previously published. In brief, individuals reside in areas defined by high-resolution population density data. Contacts with other individuals in the population are made within the household, at school, in

We assumed an incubation period of 5.1 days[9,10]. Infectiousness is assumed to occur from 12 hours prior to the onset of symptoms for those that are symptomatic and from 4.6 days after infection in those that are asymptomatic with an infectiousness profile over time that results in a 6.5-day mean generation time. Based on fits to the early growth-rate of the epidemic in Wuhan[10,11], we make a baseline assumption that R_0=2.4 but examine values between 2.0 and 2.6. We assume that symptomatic individuals are 50% more infectious than asymptomatic individuals. Individual infectiousness is assumed to be variable, described by a gamma distribution with mean 1 and shape parameter α=0.25. On recovery from infection, individuals are assumed to be immune to re-infection

Disease Progression and Healthcare Demand

Analyses of data from China as well as data from those returning on repatriation flights suggest that 40-50% of infections were not identified as cases[12]. This may include asymptomatic infections, mild disease and a level of under-ascertainment. We therefore assume that two-thirds of cases are sufficiently symptomatic to self-isolate (if required by policy) within 1 day of symptom onset, and a mean delay from onset of symptoms to hospitalisation of 5 days. The age-stratified proportion of

Table 2: Summary of NPI interventions considered.

Label	Policy	Description
CI	Case isolation in the home	Symptomatic cases stay at home for 7 days, reducing non-household contacts by 75% for this period. Household contacts remain unchanged. Assume 70% of household comply with the policy.
HQ	Voluntary home quarantine	Following identification of a symptomatic case in the household, all household members remain at home for 14 days. Household contact rates double during this quarantine period, contacts in the community reduce by 75%. Assume 50% of household comply with the policy.
SDO	Social distancing of those over 70 years of age	Reduce contacts by 50% in workplaces, increase household contacts by 25% and reduce other contacts by 75%. Assume 75% compliance with policy.
SD	Social distancing of entire population	All households reduce contact outside household, school or workplace by 75%. School contact rates unchanged, workplace contact rates reduced by 25%. Household contact rates assumed to increase by 25%.
PC	Closure of schools and universities	Closure of all schools, 25% of universities remain open. Household contact rates for student families increase by 50% during closure. Contacts in the community increase by 25% during closure.

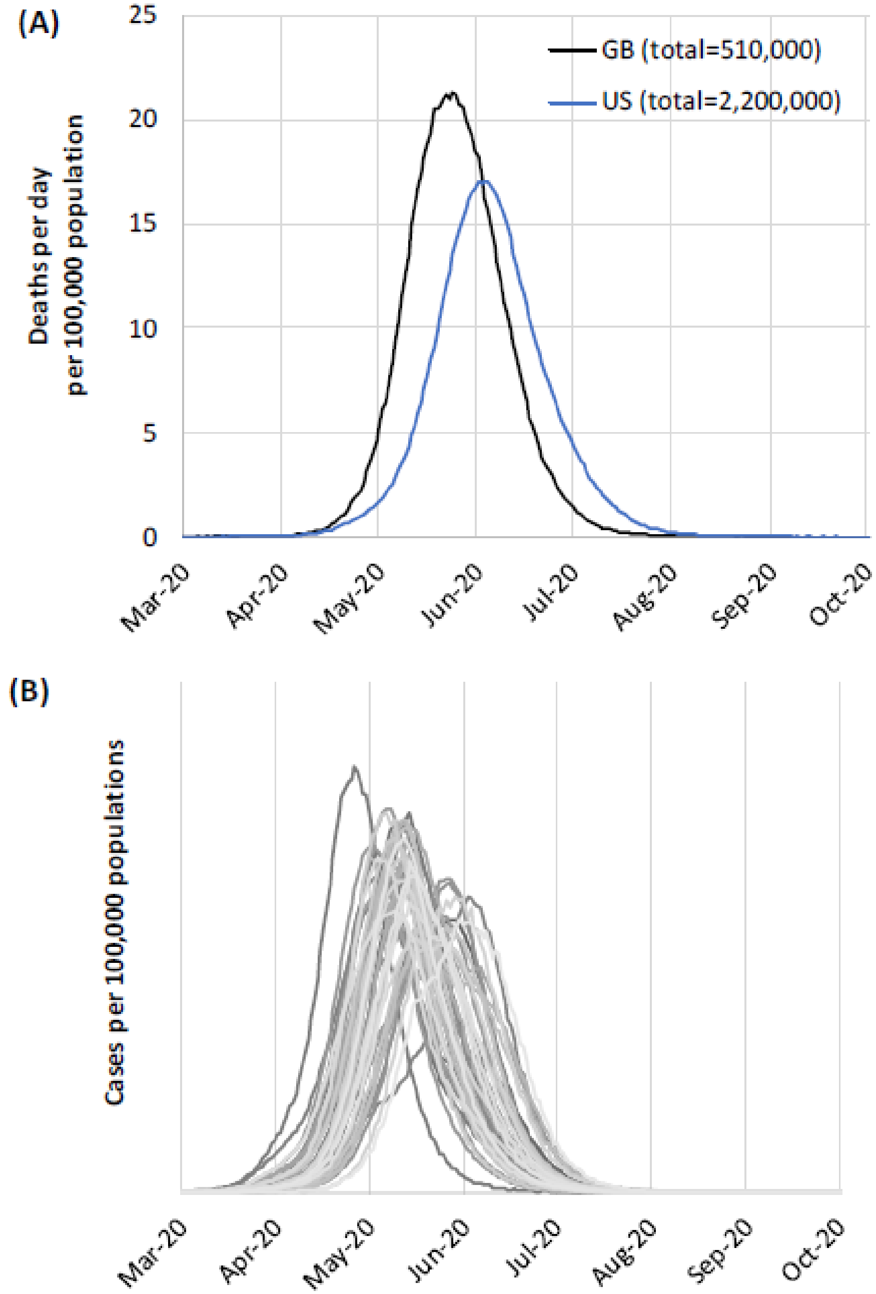
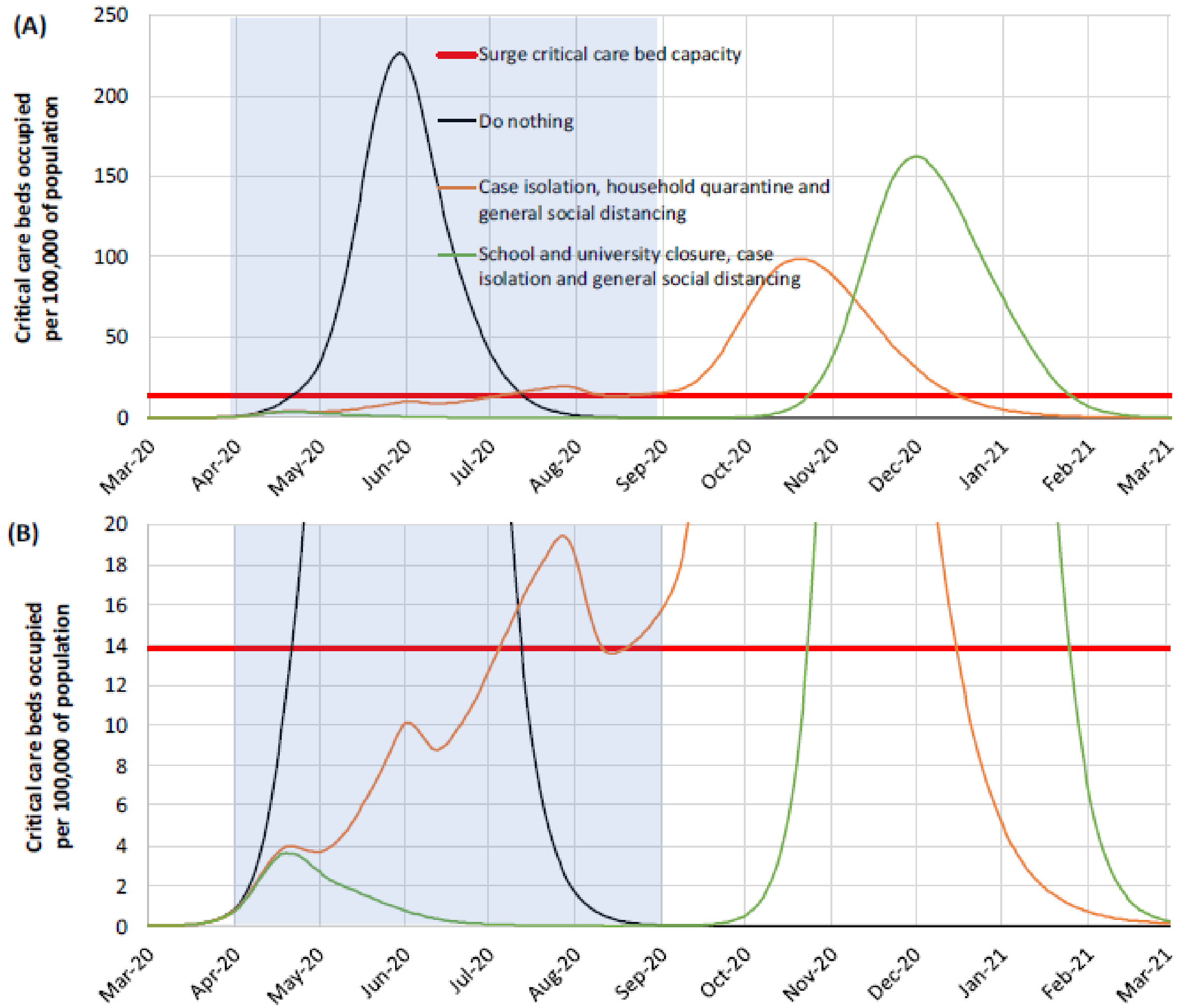


Figure 1: Unmitigated epidemic scenarios for GB and the US. (A) Projected deaths per day per 100,000 population in GB and US. (B) Case epidemic trajectories across the US by state.

Appendix

Figure A1: Suppression strategy scenarios for US showing ICU bed requirements. The black line shows the unmitigated epidemic. Green shows a suppression strategy incorporating closure of schools and universities, case isolation and population-wide social distancing beginning in late March 2020. The orange line shows a containment strategy incorporating case isolation, household quarantine and population-wide social distancing. The red line is the estimated surge ICU bed capacity in US. The blue shading shows the 5-month period in which these interventions are assumed to remain in place. (B) shows the same data as in panel (A) but zoomed in on the lower levels of the graph.



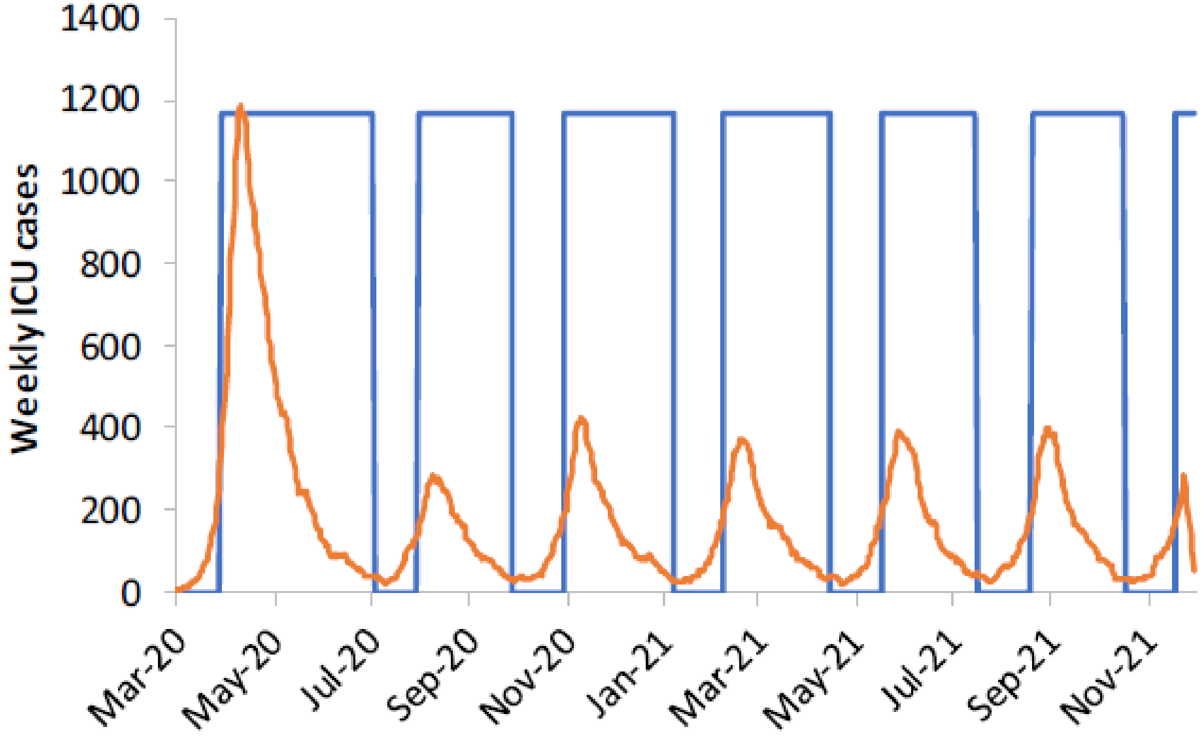


Figure 4: Illustration of adaptive triggering of suppression strategies in GB, for R_0=2.2, a policy of all four interventions considered, an "on" trigger of 100 ICU cases in a week and an "off" trigger of 50 ICU cases. The policy is in force approximate 2/3 of the time. Only social distancing and school/university closure are triggered; other policies remain in force throughout. Weekly ICU incidence is shown in orange, policy triggering in blue.

The Authors

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▪ SUMMARY

Imperial College Scientist Who Inspired the U.S. and U.K. Coronavirus Lockdowns Is in Self-Isolation

THE THANKS HE GETS

Prof. Neil Ferguson, who warned that over 2 million Americans would die unless Trump changed course, is experiencing classic COVID-19 symptoms and went into self-isolation.

Nico Hines
London Editor

Updated Mar. 18, 2020 5:34PM ET / Published Mar. 18, 2020 8:00AM ET

REUTERS

LONDON—The scientist behind a bombshell coronavirus study that reportedly shocked Washington and London out of their light-touch response to the pandemic has gone into self-isolation after experiencing symptoms of COVID-19.

Prof. Neil Ferguson, whose terrifying Imperial College report has been cited by the White House and Downing Street, said this morning that he had come down with the classic symptoms of a persistent dry cough and fever.

He was present at a press conference with Prime Minister Boris Johnson at No. 10 just 24 hours before his symptoms first appeared.

Not everyone is convinced …

Bill Gates addresses coronavirus fears and hopes in AMA

Devin Coldewey @techcrunch / 3:45 pm EDT • March 18, 2020

Q: What about this Imperial College study suggesting 1-4 million Americans will die with current approaches, but total shutdown would limit deaths to a few thousand?

Fortunately it appears the parameters used in that model were too negative. The experience in China is the most critical data we have. They did their “shut down” and were able to reduce the number of cases. They are testing widely so they see rebounds immediately and so far there have not been a lot. They avoided widespread infection. The Imperial model does not match this experience. Models are only as good as the assumptions put into them. People are working on models that match what we are seeing more closely and they will become a key tool. A group called Institute for Disease Modeling that I fund is one of the groups working with others on this.

FIRST OPINION

A fiasco in the making? As the coronavirus pandemic takes hold, we are making decisions without reliable data

By JOHN P.A. IOANNIDIS / MARCH 17, 2020

The current coronavirus disease, Covid-19, has been called a once-in-a-century pandemic. But it may also be a once-in-a-century evidence fiasco.

At a time when everyone needs better information, from disease modelers and governments to people quarantined or just social distancing, we lack reliable evidence on how many people have been infected with SARS-CoV-2 or who continue to become infected. Better information is needed to guide decisions and actions of monumental significance and to monitor their impact.

Draconian countermeasures have been adopted in many countries. If the pandemic dissipates — either on its own or because of these measures — short-term extreme social distancing and lockdowns may be bearable. How long, though, should measures like these be continued if the pandemic churns across the globe unabated? How can policymakers tell if they are doing more good than harm?

Opinion

Is Our Fight Against Coronavirus Worse Than the Disease?

There may be more targeted ways to beat the pandemic.

By David L. Katz
Dr. Katz is president of True Health Initiative and the founding director of the Yale-Griffin Prevention Research Center.

We routinely differentiate between two kinds of military action: the inevitable carnage and collateral damage of diffuse hostilities, and the precision of a "surgical strike," methodically targeted to the sources of our particular peril. The latter, when executed well, minimizes resources and unintended consequences alike.

Immunity occurs when our immune system has developed antibodies against a germ, either naturally or as a result of a vaccine, and is fully prepared should exposure recur. The immune system response is so robust that the invading germ is eradicated before symptomatic disease can develop.

Importantly, that robust immune response also prevents transmission. If a germ can't secure its hold on your body, your body no longer serves as a vector to send it forward to the next

My take …

- Gates and Ioannidis are partly right – there is a certain amount of arbitrariness about the precise numbers they use
- But I think this obscures the bigger point, that the *dynamics* of the disease are more important than the precise numbers generated
- The “herd immunity” argument seems very risky
- We probably do need *suppression* as well as *mitigation*
- I am a little puzzled that the Imperial College paper didn’t mention the *testing* issue

Conclusions

- Measures being undertaken in various states of US (including NC) are almost certainly necessary and may not be strong enough
- On an individual level, we all need to take this very seriously and practice *social distancing* as much as we can

If you have questions or feedback ..

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