

How can we help stop the COVID-19 pandemic?

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Abstract

The new coronavirus has already claimed the lives of hundreds of thousands of people. Different countries are taking different measures in the fight against this new threat. Many people are staying at home. But is it worth it? That's what we wanted to find out.

We created a computer model that helps us assess the effect of different measures against COVID-19. We checked for the

impact on people's health and the state of the healthcare systems in two countries: the UK and the US. We found that social distancing of the whole population, not just the elderly, would have the most beneficial effect. The combination of this measure with others would be even better.

Introduction

Tired of staying at home and hearing about the new *coronavirus*? Perhaps you wonder: is it even worth it? What is the purpose behind it? In just a few months, the new virus has spread around most of the world and claimed the lives of hundreds of thousands of people. With so many lives at stake and with healthcare systems reaching their limits, many governments are wondering what their options are:

- *Vaccine*? This would be the best option, but it can take a long time to produce a safe and effective one.
- *Medicine*? Also a good potential option - many studies are underway. So far there is no effective treatment available.

While we are waiting for these life-saving *pharmaceuticals*, we have to rely on other (non-pharmaceutical) measures:

1. *Mitigation* of the *epidemic* – the aim is to protect the most vulnerable people in the population: people over 70 and people with other health problems. Meanwhile, the rest of the population could achieve *herd immunity*.
2. *Suppression* of the epidemic – the aim is to minimize the spread of the virus until a vaccine or an effective treatment is available.

We set out to compare these two strategies. Which one will result in fewer deaths? Which one will relieve the healthcare systems?



People who work in grocery stores are called "essential workers" because they ensure everyone can get enough food during the crisis.

Methods

To answer these questions about the *COVID-19* pandemic, we modified a *computer model* developed for flu pandemic simulations. It represents viral *transmission* between individual people in the UK and the US. In our model we made the following *assumptions* (based on data from the current pandemic):

- The average *incubation period* of the virus is about 5 days.
- People can infect others for 12 hours before they show symptoms.
- Not all infections are diagnosed – 40-50% of infected people have only mild or no symptoms at all.
- When people don't develop any symptoms, they can transmit the virus for up to 5 days after infection.
- Symptomatic people are 50% more infectious than asymptomatic people.

Table 1:
Interventions we consider in our model

Measure	Description
Case isolation in the home	People with symptoms stay at home for 7 days and reduce contact with the outside world.
Voluntary home quarantine	People who share a household with a symptomatic person also stay at home for 14 days.
<i>Social distancing</i> of people over 70 years of age	People over 70 years of age (and people with health problems) reduce contact with the wider community but, as a result, increase contact within the household.
Social distancing of the entire population	All people reduce contact outside their households, regardless of their age or health.
Schools and universities close	Students reduce contact outside their households but increase contact inside.

- One infected person transmits the virus to 2.4 new people on average. (This number is called "*reproduction number*", or R_0 .)
- The *infection fatality ratio* (IFR) is around 1%.
- Around 4% of infected people need hospitalization.
- Of the hospitalized people, around 30% need critical care (breathing with the help of a machine).
- Of those who need critical care, about half die.
- The stay in the hospital is on average 8 days when there is no need for critical care and 16 days when critical care is required (10 of which are in an Intensive Care Unit).

In our model, about one third of transmissions take place in the household, one third in schools and workplaces, and the remaining third in the community.

What are the different measures we consider? Table 1 shows these measures and their descriptions.

Let's see what impact they have on the transmission of the virus and on the healthcare systems.

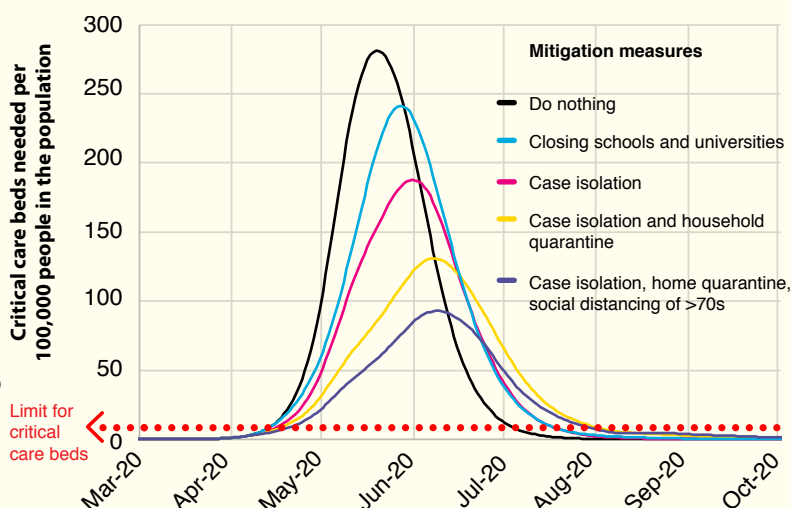
Results

What would a mitigation strategy achieve?
Check out Figure 1.

Which combination of measures gives the best results? Is it sufficient?

Figure 1:

Predictions for mitigation measures in the UK. The graph shows the impact of the different mitigation scenarios on the healthcare systems - how many beds for critical care are available and how many people will need them.



We calculated the reduction of deaths as a result of each scenario. We found that the best mitigation scenario is a combination of case isolation, home quarantine and social distancing for the elderly. However, even within this best scenario, the healthcare systems would be overwhelmed and hundreds of thousands of people would die.

What about suppression measures? Figure 2 shows the impact of a 5-month suppression scenario.

Again, we calculated the reduction of deaths. Our results suggest the best strategy would be to combine all four interventions: case isolation, household quarantine, social distancing of the entire population and shutting down all schools and universities. Still, this would lead to a second wave of cases later.

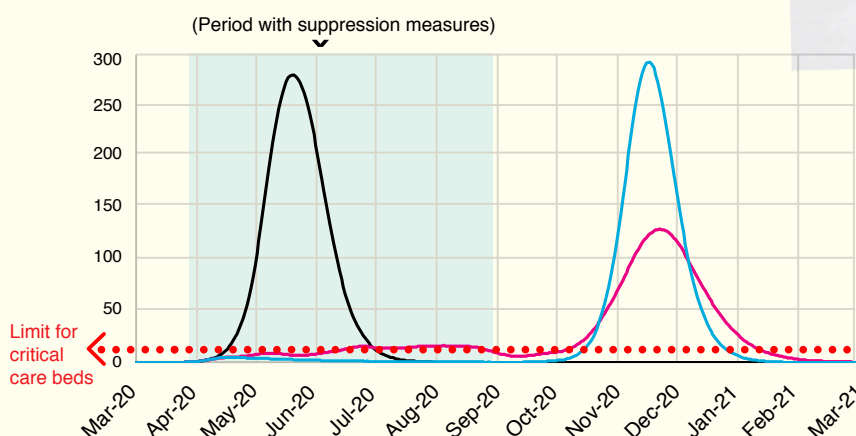
What will a suppression strategy achieve?

Figure 2:
Predictions for suppression measures in the UK.

**Suppression measures
(for a 5-month period)**

- Do nothing
- Schools and universities closure, case isolation and general social distancing
- Case isolation, household quarantine and general social distancing

Critical care beds needed per 100,000 people in the population



If governments don't take any control measures, around 80% of the UK and US population could be infected within a few months. In that case, half a million people would die in the UK and more than 2 million would die in the US (because the US population is bigger). The healthcare systems of both countries would exceed their limits as early as the second week of April 2020.

Discussion

Our results are clear that suppression is the far better strategy against COVID-19 for now. Social distancing of the entire population would have the largest impact on both people's health and the healthcare system. In addition, it's best to combine this measure with others, such as home isolation and the closure of schools and universities. According to our model, this scenario would greatly reduce the number of cases and thus the number of deaths.

Every model has limitations. Our model doesn't account for economic and other social and political impacts. We expect

that many countries would struggle to afford these extreme measures. Moreover, for viral suppression to be successful, it has to take place over a long time. Ideally, until a vaccine is available, which could take as long as a year and a half.

In countries where this is not an option, the preferred policy would be a combination of case isolation, self-quarantine and social distancing of the elderly. Sadly, this would lead to more deaths and healthcare system overload.

Conclusion

Even though it's frustrating and tiring, you should know that staying at home is one of the best things you can do right now. This helps you and thousands of other people.

Also remember to wash your hands with soap often and carefully, for at least 20 seconds.

This article is pending review.

Glossary of Key Terms

Assumption – something that is accepted as true based on the current scientific understanding.

Coronaviruses – a group of closely related viruses that usually cause respiratory infections in humans. Sometimes they cause symptoms and sometimes they do not. Symptoms can be mild or severe, and can include pneumonia, coma, death. Well-known coronaviruses are SARS-CoV (severe acute respiratory syndrome coronavirus), MERS-CoV (Middle East respiratory syndrome coronavirus) and SARS-CoV-2 – the virus causing the current pandemic.

COVID-19 – **C**oronavirus **d**isease 2019, a disease caused by SARS-CoV-2, symptoms may include fever and dry cough in milder cases and difficulty breathing in more severe cases.

Epidemic – A sudden increase in the number of disease cases in a particular population.

Herd immunity – As more and more people in a population become immune either through recovery from infection or through vaccination, the chance that a disease can spread decreases. Everyone benefits from extra protection thanks to people who are already immune. When enough people are immune, they act as a shield for vulnerable people, and so the opportunity for disease to spread becomes so low that we say this population has herd immunity.

Incubation period – the time between catching the virus and the appearance of the first symptoms.

Infection fatality ratio (IFR) – during an epidemic, the proportion of all infected people who die. It's different from the case fatality ratio (CFR) – the proportion of all people with a disease who die. IFR attempts to account for asymptomatic and undiagnosed infections, CFR does not.

Model – a set of mathematical equations that attempts to simulate a system (for example human society) and so to predict how the system would behave in the real world.

Mitigation of the epidemic – the aim is to reduce spread while protecting the most vulnerable people. It only slows down the epidemic, allowing herd immunity to build up more slowly than without mitigation.

Pharmaceuticals – substances manufactured for use as medicinal drugs to treat disease or as vaccines to prevent disease.

Reproduction number (R_0) – a specific number for a pathogen during an epidemic measuring the average number of new infections generated by an infected person in a population with no immunity.

Social distancing – deliberately increasing the space between people to avoid the spreading of illness.

Suppression of the epidemic – the aim is to minimize the transmission of the virus. Thus there will be just a few new cases but when the measures stop, the epidemic could restart. The measures are stronger than mitigation, with social distancing of the entire population being the most important one.

Transmission – the passing of a bacterium, a virus or another pathogen from one person to another.

Vaccine – a person receives parts of a virus or bacterium or weakened versions of the pathogen and develops antibodies against them without getting sick: the immune system now knows how to fight this type of infection. For instance, most children receive Measles, Mumps and Rubella vaccine (MMR) to prevent getting these diseases in the future.

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Check your understanding



1 Is your country suffering from a COVID-19 epidemic? What measures is your government taking? Would you categorize them as mitigation or suppression?

2 What is one advantage of the mitigation strategy?

3 What is one disadvantage of the suppression strategy?

4 When you look at Figure 2, why is there another peak in infections in November?

5 What would happen if governments took no measures against the epidemic?
