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Epidemic Prediction of COVID-19 Using Mathematical Modeling

Finding ways to prevent a medical system breakdown

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We estimated the change in the number of people infected with the new coronavirus based on a mathematical model. Given that the basic reproduction number (the expected number of secondary cases transmitted by each infectious person) is **2.5**, which is the average number in other countries, a substantial number of people will be infected at the peak.

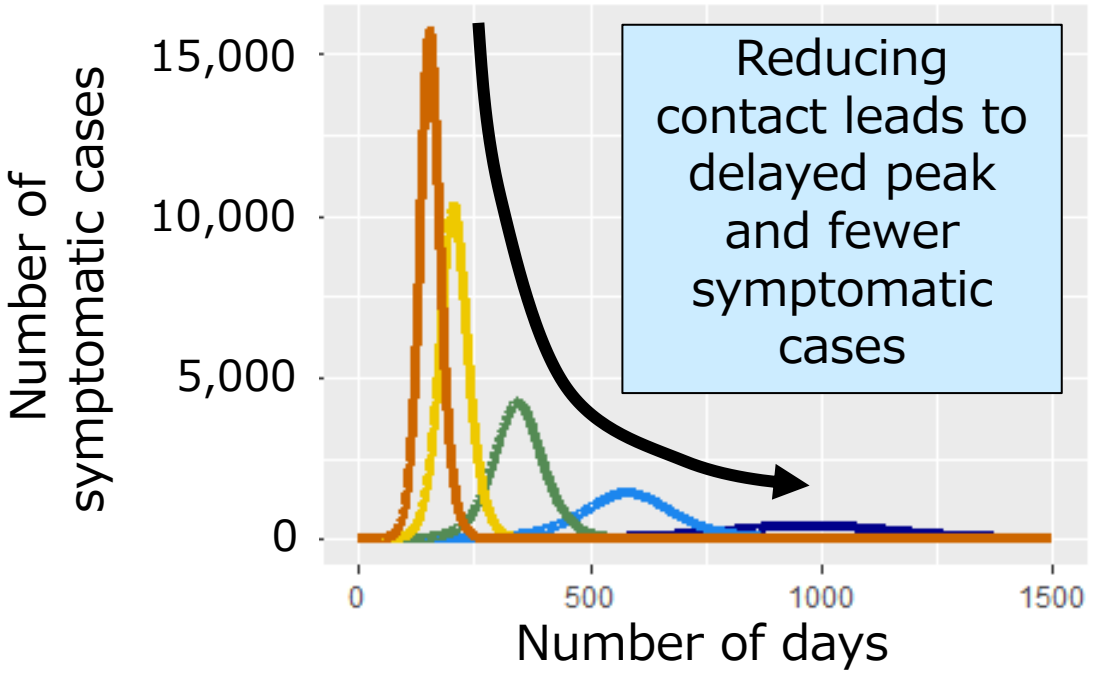
Unless we immediately reduce contact with other people to nearly **40%**, the **medical system will collapse** due to an explosive surge of patients.

Importantly, the overall impact of social distancing on reducing COVID-19 cases will be diminished if 1% of asymptomatic carriers of the virus do not change their behavior.

Whether we can prevent the medical system from collapsing is completely up to our actions!

Predicted number of symptomatic cases:

when all symptomatic cases reduce contact with other people (in the case of no asymptomatic carriers)



Contact frequency of symptomatic cases is reduced to

- 45%
- 50%
- 60%
- 80%
- 100% (no change)

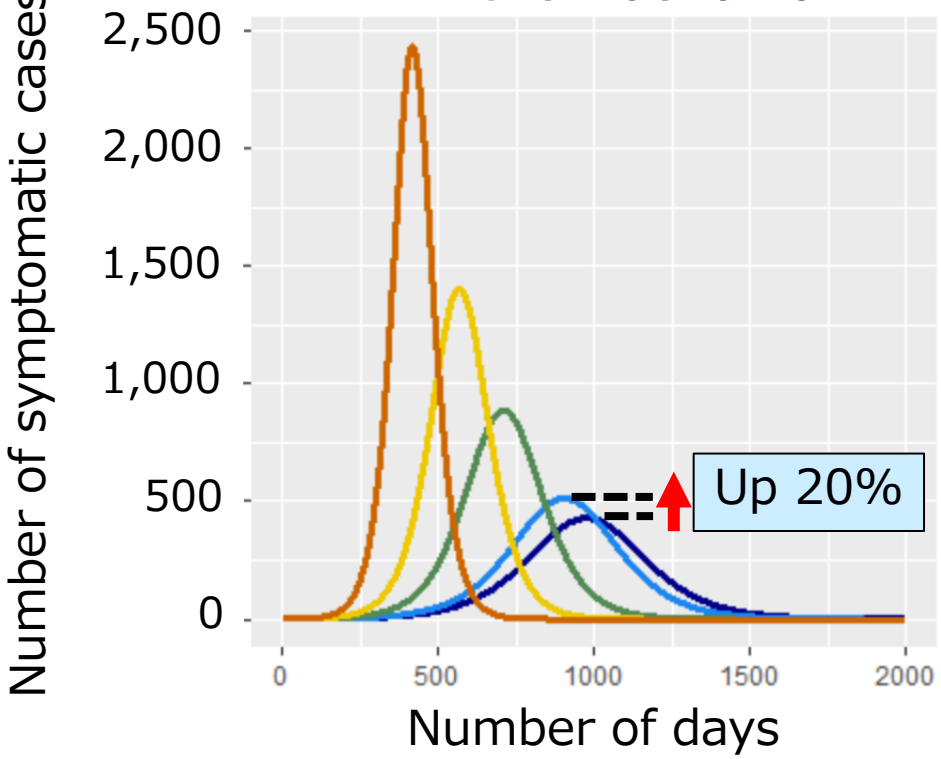
The model assumes that 1 infectious person (symptomatic case) appeared in a city with a population of 100,000 on Day 0 and all infected people become symptomatic cases.

Reducing contact with others delays the peak and leads to a significant reduction in the number of symptomatic cases.

→ It is important to reduce contact as much as possible.

Predicted number of symptomatic cases :

in the presence of asymptomatic carriers who do not change their behavior



Assuming all symptomatic cases reduce their contact frequency to 45%

1% of asymptomatic carriers who do not change their contact frequency with others will lead to a 1.2-fold increase of symptomatic cases at the peak, even if 99% of symptomatic cases reduce their contact frequency to 45%.

We may be asymptomatic carriers unknowingly infected.

→ ALL of us need to reduce our contact with others.

Because there are a certain number of **asymptomatic carriers** (a person who has no symptoms but can infect others) of COVID-19, **everyone, including uninfected people,** must reduce contact with other people to protect themselves from infection and to avoid unconsciously infecting others.

However, even if social distancing successfully stops the spread of COVID-19 in Japan, it is still possible that another rapid spread of infection from inbound and outbound travelers could occur anytime if travel restrictions are lifted.

It would be a long battle but if all of us do our part in controlling our behavior, we can safely buy time for developing effective treatments (including vaccinations). By preventing a catastrophic spread of infection, we can overcome this crisis.

Supplementary information

The susceptible-exposed-infected-recovered (**SEIR**) model was used to calculate the number of symptomatic cases over time. The SEIR model uses ordinary differential equations to calculate the change in the number of people in the following four compartments.

For the parameters used and the model including asymptomatic carriers, see the detailed version on the website of the Department of Biological Sciences, Graduate School of Science, the University of Tokyo.

The calculations were made with the assumption that **only infectious people with symptoms** reduce their contact with other people. “Contact” in this simulation represents transmissible contact. Hospitalization and isolation of infectious people were not taken into account in this model.

A medical system collapses when the number of patients who need to be hospitalized exceeds the number of patients that can be accepted by medical institutions. In such a situation, patients who would otherwise have survived die without being hospitalized. The Tokyo Metropolitan Government is trying to secure 4,000 beds for COVID-19 patients.