Investigation of efficiency of mask wearing during COVID-19 outbreak

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Abstract

A lot of interventions have been introduced by countries to control and prevent COVID-19 epidemic. Case isolation and identification of contacts are an essential part of these control measures. If infectiousness starts before the symptoms onset, like with COVID-19, then the controlling outbreak through contact tracing and case isolation is more difficult and requires additional interventions, for example, masks wearing. There are various approaches to the mask using during the epidemic and, therefore, they can have different effects on the disease transmission preventing.

Problem description

In epidemic theory the basic reproduction number R_0 is the main parameter which describes disease spread. R_0 is defined as the average number of people that one infected person can infect. If $R_0 < 1$ the infection will eliminate. In order to analyze the effect of 3 different interventions (case isolation, contact tracing, mask wearing) on the epidemic spread we used a stochastic model, that is a branching process.

We consider 3 scenarios for masks wearing:

1) Mask prevents spreading and infected person wears it only after onset of symptoms;
2) Mask prevents spreading and all (infected and suscepted) people wear masks;
3) Mask prevents spreading and protects healthy persons from getting infection, and all people wear masks.

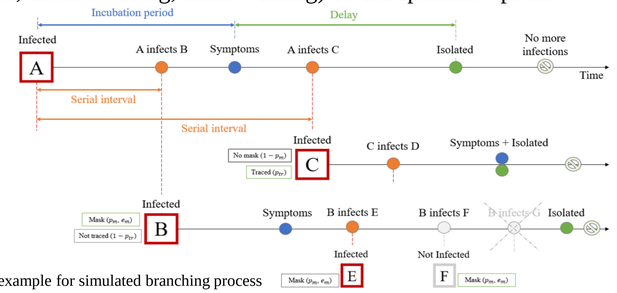

Fig. 1. Scenario example for simulated branching process

Discussion

For each simulation we estimate the mean value of R_0 which here is called effective reproduction number R_{eff}. When only isolation and contact tracing are assumed, R_{eff} decreases but only 100% probability of tracing brings median value of R_{eff} to 1, which means that a disease is just stable – without growing or dropping. If we consider third scenario for mask wearing, then the median value of the effective reproduction number becomes smaller than 1 relatively fast.

For this model outbreak control was also simulated. An outbreak was defined as controlled if it did not exceed in total 5000 cases in 3 months and no new cases were found in the following month. Mask using only after symptoms onset is not very efficient to achieve a reasonably high level of control under outbreak. But when 70% of all people wear masks, there is almost 70% probability of the outbreak control even without contact tracing, and with 60% efficiency of contact tracing the outbreak can be controlled with almost 100% probability.

Results

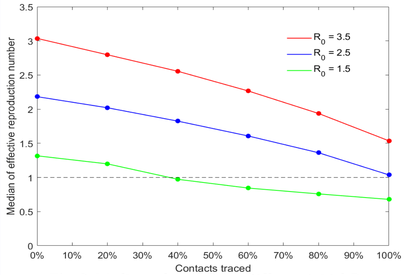

Fig. 2. Median value of R_{eff}. Different initial R_0 (without mask wearing)

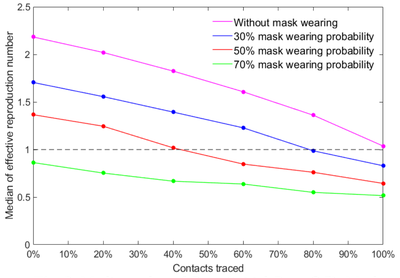

Fig. 3. Median value of R_{eff} (initial $R_0 = 2.5$). Mask prevents spreading and protects from getting infection

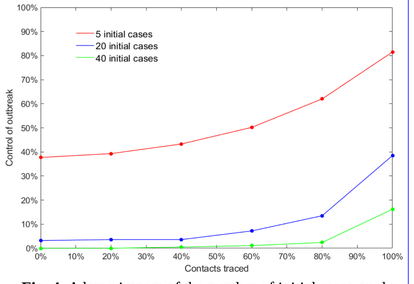

Fig. 4. A large impact of the number of initial cases on the probability of achieving control (initial $R_0 = 2.5$)

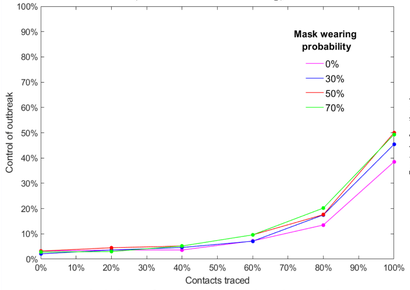

Fig. 5. Probability of controlling outbreak. Mask prevents spreading and it is worn only after symptom onset

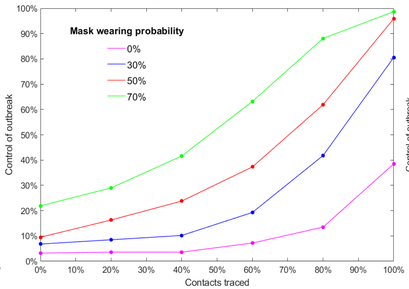

Fig. 6. Probability of controlling outbreak. Mask prevents spreading and all people wear masks

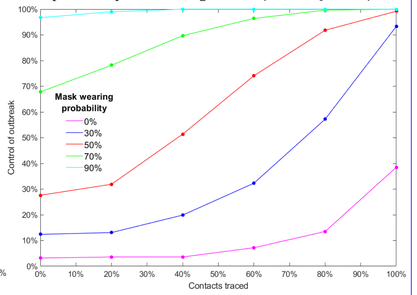

Fig. 7. Probability of controlling outbreak. Mask protects from both sides and all people wear masks

Conclusions

- The investigated 3 different types of interventions (case isolation, contact tracing and mask wearing) are enough to control the new COVID-19 outbreak.
- In some scenarios, case isolation together with contact tracing are not enough to control the spread of the disease within 3 months (Fig. 4-5).
- Wearing of masks only by infected people after their symptom onset doesn't have strong effect on the situation (Fig. 5).
- The outcomes change significantly when all people wear masks. For all 3 considered probabilities of masks wearing the 100% contacts tracing can lead to more than 90% probability of the outbreak control (Fig. 6-7). If we consider an almost ideal case – when 90% of people wear masks – the control of the outbreak occurs immediately (Fig. 7).
- Effective contact tracing, case isolation and high probability of mask wearing can provide us the control measures from the disease spread and prevent over a longer period of time.

References

[1] World Health Organization. (2020). Advice on the use of masks in the context of COVID-19: interim guidance, 5 June 2020. World Health Organization. WHO/2019-nCov/IPC_Masks/2020.4

Acknowledgements

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