CONTACT-TRACING STRATEGIES FOR SARS-COV-2 ERADICATION **** UNFINISHED DRAFT ****

Daniel Tang
Leeds Institute for Data Analytics*
University of Leeds
Leeds, UK
D.Tang@leeds.ac.uk

March 27, 2020

ABSTRACT

As of 27^{th} March a large and increasing proportion of the global population are living under social distancing measures in order to control the spread of COVID-19. If these measures are successful we will, in a few months, be in a situation where prevalence is again low in certain parts of the world, however, it is not clear what the best policy will be at that point. This paper investigates the feasibility of using contact tracing along with a combination of other measures in order to ease the social distancing measures while preventing a resurgence of the disease.

****** THIS IS UNFINISHED RESEARCH WHICH MAY CONTAIN ERRORS AND IS SUBJECT TO CHANGE ******

***K*eywords** COVID-19, SARS-CoV-2

1 Introduction

Many countries in the world are now committed to a surge in incidence of COVID-19 and are practising social distancing in order to suppress the spread. If successful, these countries will soon be in a situation where prevalence is reducing. Once this is achieved there are a number of strategies:

- lift the social distancing measures and allow a second (and subsequent) waves until herd immunity is achieved(Ferguson et al., 2020).
- maintain low levels until a vaccine is available
- eradicate the virus locally and impose strict border controls and containment strategies until the virus is contained globally

Here we investigate the feasibility of the third option by slowly lifting social distancing measures while maintaining self isolation of symptomatic individuals and implementing an extensive testing and contact-tracing capability.

2 The Model

In order to do this we modify the stochastic branching model described in (Hellewell et al., 2020). Our model differs from the Hellewell et.al. model in the following ways

- The model was re-implemented as a discrete-event model in order to capture the dynamics of the positive feedback between the number of cases and the delay in obtaining test results[2] [this feedback has yet to be implemented].

*This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 757455)

[2]Although a discrete-event simulation is slower, execution time is not a bottleneck so it is worthwhile in order to capture the dynamics.

- The location of infection (household, school/workplace or community) was modelled. This allows us to capture the differences in ease and speed of contact tracing in these three cases, and to capture the effect of different policies for tracing in these contexts. It also allows us to capture the effect of household-wide self-isolation policies such as those implemented in the UK. The relative probability of transmission in the three locations was calibrated in order to obtain equal numbers of transmission events in each location, following (Ferguson et al., 2020). The size distribution of households was calibrated against(Smith, 2014).

- The overdispersion, k, of R was set to 10.0 in order to reflect the much lower probability of superspreading of COVID-19 compared to SARS reported in (Zhuang et al., 2020) and (Riou & Althaus, 2020)

- The infectivity of asymptomatic carriers was reduced to 0.66 that of symptomatics following (Ferguson et al., 2020)

- The proportion of subclinical cases was set to 17.9% in line with (Mizumoto, Kagaya, Zarebski, & Chowell, 2020)

- We add the ability to make a proportion of the population immune, in order to account for people who became infected during the first wave of infection. This immunity is applied only to school/workplace and community under the assumption that, during the peak, under "stay at home" rules, if one member of a household contracts the disease it is highly likely that all other members will also contract it, and so the whole household will become immune. This means that only members of non-immune households can subsequently become infected.

The source code of the model is available at https://github.com/danftang/Covid19

3 Preliminary results

Simulations were carried out to find the probability that an initial population of 100 infected could be eradicated under different scenarios. Eradication was deemed to have been achieved if the cumulative number of cases remained below 5000 and there was no untraced infected population at 15 weeks into the simulation. $R0$ was set to 2.4 and it was assumed that 5% of the population was immune. It was also assumed that 15% of transmission events occur before symptom onset.

3.1 Policy and Tracing strategy

It was assumed that a "self-isolate" policy was in place such that anyone who becomes symptomatic must self-isolate and report to authorities, at this point all members of that person's household also must self-isolate. It was assumed that there was a delay between symptom onset and self-isolation/reporting. At this point all members of the household are tested and those that test positive are contact-traced. Contact tracing was assumed to identify 90% of contacts in the workplace/school and 10% of contacts in the community. Symptomatic contacts in the workplace must isolate immediately, other contacts are tested and must isolate on positive test result. The time for a test result to be processed was assumed to be 24 hours. It was assumed that 10% of the population do not comply with these rules and never self-isolate.

It was found that the probability of eradication was sensitive to the delay between symptom onset and self-isolation, and to the time after exposure that an infected person would test positive. Figure 1 shows the probability of eradication against the delay between symptom onset and self-isolation while figure 2 shows the probability of eradication against the delay between exposure and positive test result.

4 Discussion

These early results are subject to further calibration of the model and are likely to change as our understanding of the dynamics of SARS-CoV-2 develops. It also remains to do a proper sensitivity analysis of the model, and to properly treat uncertainty, which is large. However, they do indicate that while it is not impossible in theory for contact-tracing to be effective, in practice we face a difficult time in the weeks ahead, and that for contact tracing to work, it is likely that it will have to be implemented in combination with some other policy or policies to suppress community transmission. Our ongoing research will investigate these possibilities.

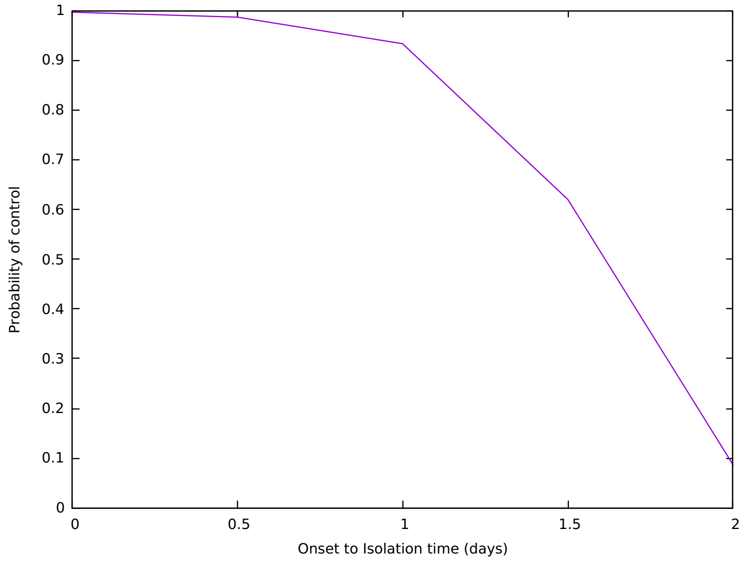

Figure 1: Probability of eradication for different delays between the onset of symptoms and self-isolation, assuming all infected test positive.

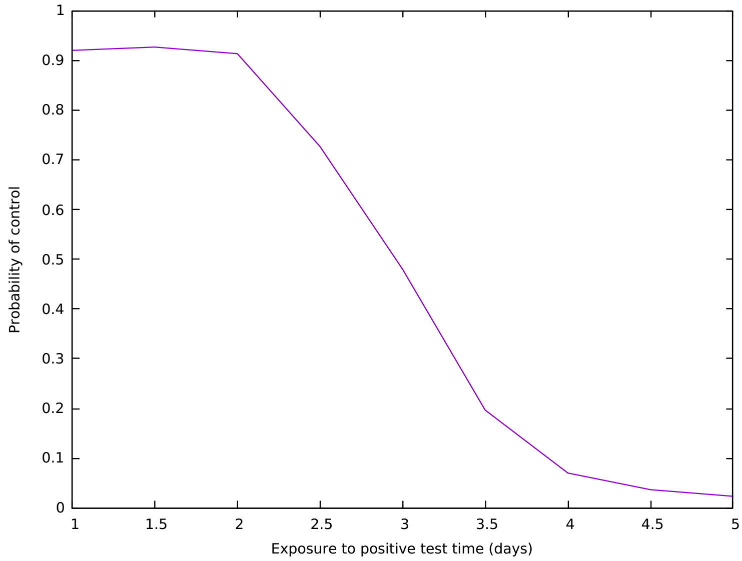

Figure 2: Probability of eradication for different delays between exposure and a test result becoming positive, assuming a delay of 1 day between symptom onset and self-isolation.

References

Ferguson, N. M., Laydon, D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M., ... others (2020). Impact of non-pharmaceutical interventions (npis) to reduce covid-19 mortality and healthcare demand. *London: Imperial College COVID-19 Response Team, March*, *16*.

Hellewell, J., Abbott, S., Gimma, A., Bosse, N., Jarvis, C., Russell, T., et al. (2020). Feasibility of controlling covid-19 outbreaks by isolation of cases and contacts. *Lancet Glob Health; published online Feb 28*.

Mizumoto, K., Kagaya, K., Zarebski, A., & Chowell, G. (2020). Estimating the asymptomatic proportion of coronavirus disease 2019 (covid-19) cases on board the diamond princess cruise ship, yokohama, japan, 2020. *Eurosurveillance*, *25*(10). Retrieved from `https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.10.2000180` doi: https://doi.org/10.2807/1560-7917.ES.2020.25.10.2000180

Riou, J., & Althaus, C. L. (2020). Pattern of early human-to-human transmission of wuhan 2019 novel coronavirus (2019-ncov), december 2019 to january 2020. *Eurosurveillance*, *25*(4).

Smith, C. (2014). Households and household composition in england and wales: 2001-11. *Office of National Statistics*. Retrieved from `https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/articles/householdsandhouseholdcompositioninenglandandwales/2014-05-29`

Zhuang, Z., Zhao, S., Lin, Q., Cao, P., Lou, Y., Yang, L., ... He, D. (2020). Preliminary estimating the reproduction number of the coronavirus disease (covid-19) outbreak in republic of korea from 31 january to 1 march 2020. *medRxiv*.