WHY STRONG SOCIAL DISTANCING?

Preliminary Results of Our COVID19 Model Without Age Cohorts

The Center of Policy Exploration, Analysis, and Simulation[1][2]

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Abstract: This paper reports on an extended SEIR simulation model developed to analyse the COVID19 epidemic and policy measures, and simulation results obtained with the model.

1. Introduction

Many countries are in the grip of COVID19. This very infectious virus is rapidly spreading and causing many fatalities. This is also the case in the Netherlands. In the past 24 hours, 63 patients died and 265 new patients were hospitalized. In total, 242 COVID19 patients died and 5560 persons were tested positively for the virus. Many have the virus but have not been tested though. So the spread is much bigger. And it will soon be much bigger. This is not the end of the outbreak.

For many people these numbers about the recent past are all they have: imagining what might happen beyond next week is hard for most people. Understanding the importance of measures also seems to be beyond the understanding of many people concerned. Here, that is, ***all*** Dutch citizens.

That is why we took the initiative to make a simulation model and apply it to the Netherlands. The model can be used to foresee plausible futures and assess the effects of policies and measures.

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[1] Disclaimers:

- We are experts in multi-scale systems modelling and simulation, not epidemiologists. We develop simulation models to help governments and NGOs make decisions in the face of complexity and deep uncertainty. Although are not epidemiologists, we nevertheless have a track record in modelling and simulating epidemics and outbreaks (including Ebola, Flu, A(H1N1), Zika, Lyme) under deep uncertainty and providing policy advice.
- This document contains Work in Progres results. No rights can be derived from the results or advice given.
- These simulation runs are generated with the simplest version of our simulation model of COVID19 in the Netherlands (without distinguishing between different age cohorts). Right after this study, we will adapt our a multi-cohort version of the model (Youngsters, Adults, Elderly) to reality. Results with that multi-cohort version of the model will be better to (ensemble) forecast ICU needs, hospital needs, and fatalities.
- The model is not calibrated to data (yet). Results are nevertheless in line with what we are currently seeing in the data provided by the RIVM. The reason why we are not calibrating (yet), is that we want our glas box models to generate results that are close to what is happening in the real world for the right reasons, without over-fitting models to data. One of the reasons is that not all data are good (e.g., in the Netherlands, not everyone with COVID19 symptoms is tested for COVID19, which is why data wrt positive testing cannot be used for calibration).
- We usually simulate models under deep uncertainty (i.e., across large uncertainty spaces). We still need to set up the uncertainty engine for COVID19. Until then, we are only showing one simulation run, which is not *the* forecast of the future. It simply is 1 simulation run. When simulating models under deep uncertainty, many simulation runs are generated, and all reasoning happens on a large ensemble of simulation runs. Not a single one. Models simulated under deep uncertainty are useful for scenario generation and and planning /policymaking in the face of uncertainty. Single model runs are illustrative at most.
- The reason we nevertheless are making these results available now is that we believe there is a strong need to understand what needs to be done (follow the advice of health authorities). Our plan of action to provide better and more detailed simulation runs is provided below (Future Work).

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2. The Simulation Model

The model used in this paper is an extended SEIR model[3]. SEIR stands for Susceptible, Exposed, Infected, and Recovered (or dead). The basic structure of the infection-population model is visualized in Figure 1. As can be seen, the model contains asymptomatic infections, infections with only Mild (M) symptoms (S), infections with mild before (bf) Heavy (H)symptoms, and infections with mild before heavy before Extreme symptoms. Moverover, infected individuals can go into isolation or not. Finally, those who have extreme symptoms can also go to Intensive Care (IC), if and only if there is enough intensive care capacity (see Figure 2). The reason why this is modelled with these different (read: separated) ultimate-severity-of-symptoms pathways has to do with the way in which data and information is reported on.

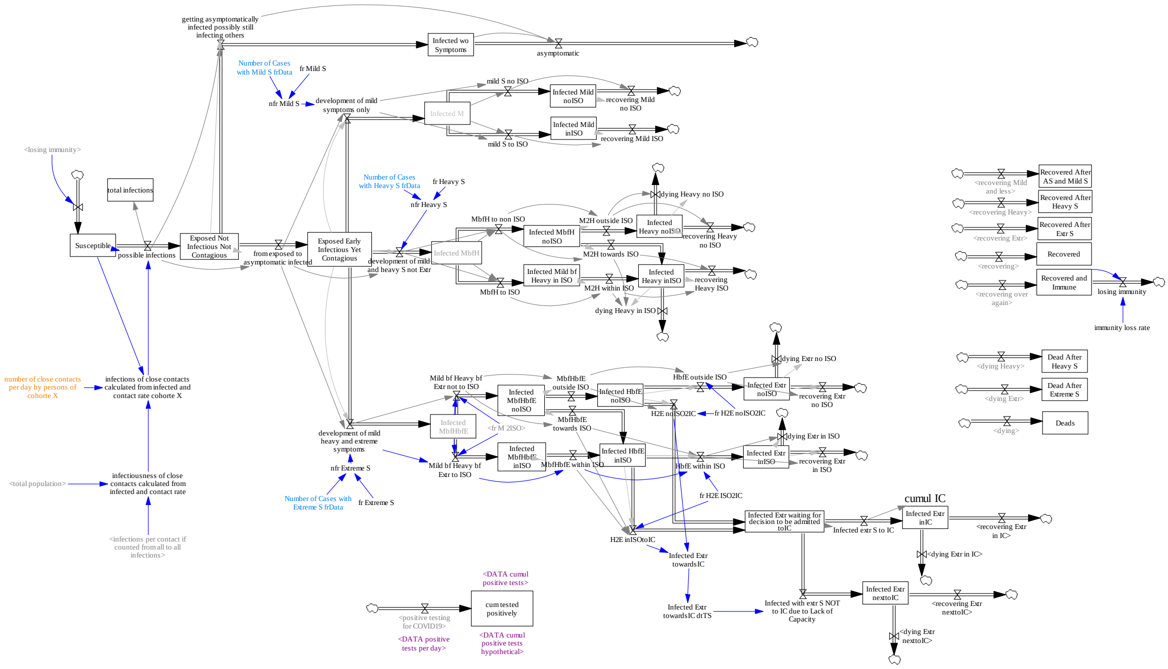

Figure 1: Simplified visualization of the basic simulation model, including different ultimate-severity-of-symptoms pathways and different options for isolation (or not)

In the version of the model used here, we explicitly modelled contact rates in different situations (no isolation, quarantine, isolation, ICU), infectivity of different levels of severity of symptoms, and the sizes of the respective combined disease cohorts/isolation levels[4].

Not included in this version of the model or simulations generated with it:

- Although different age cohortes are included, we have not activated them in this version.
- The effect of the state of the health system on the development of COVID19 in individuals (i.e., better help early on might keep infected with heavy symptoms from ending up becoming infected with extreme symptoms).

[3] It is a traditional System Dynamics simulation model. It model was made and is simulated with Vensim DSS double precision.
[4] Included in the model but not used in the simulations shown here is the calcluation of infections using R0 and R.

- The potential effect UV light / summer on COVID19 spreading.
- Other diseases with simular symptoms (flu, cold, other virusses), and false positives/negatives.
- Herd immunity (except for full immunity after the entire population is infected).
- The international context (which we will include in future work).

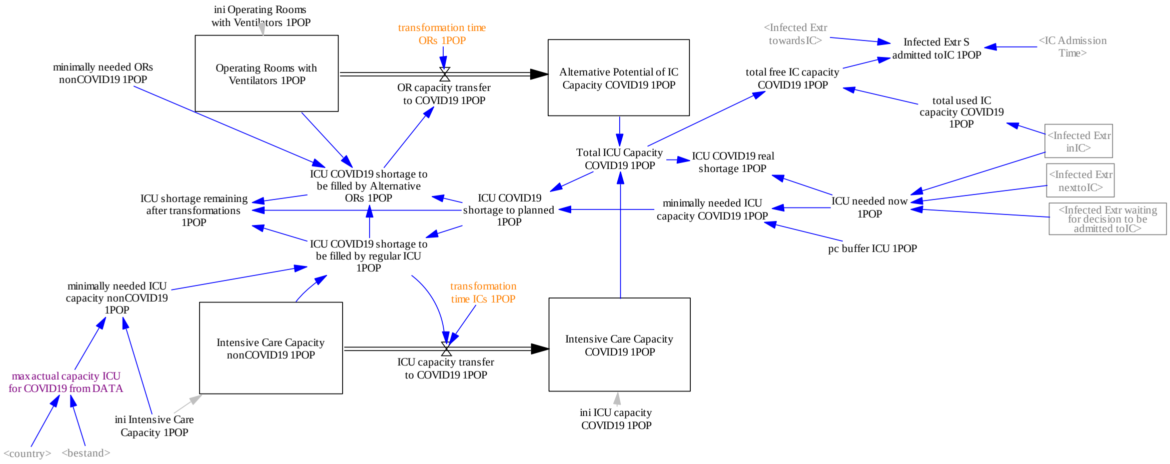

Figure 2: Intensive Care Unit (ICU) capacity submodel – all capacity submodels (i.e., ICUs / hospitals / doctors and nurses / ventilators) are built up in a similar way

3. Data and Estimates

Parameter settings will be added here later.

4. BaseCase Simulation and Comparison to Data

We are using daily data from the RIVM (the Dutch Health Institute) to assess whether our simulations make sense: positively tested, patients in ICUs, patients in hospital, fatalities. So far we are simply comparing simulation runs with data. We are not fitting the model to the data. Figure 3 shows four graphs in which the BaseCase simulation run is compared to RIVM data for the first 27 days (26/02/2020 till 23/03/2020) of the outbreak in the Netherlands. As one can see, there is a good fit between the BaseCase simulation run and data.

Note, in the bottom right graph, that we calculated what we believe should be a good proxy for the number of positive tests (the green line) if all suspected cases would be tested. That is, not all suspected COVID19 individuals are tested in the Netherlands. To calculate the variable “DATA cumul positive tests hypothetical”, we use the number of COVID19 infected individuals in hospital in combination with the information that 14.5 percent of all COVID19 infected ended up in hospital before exhaustive testing was suspended.

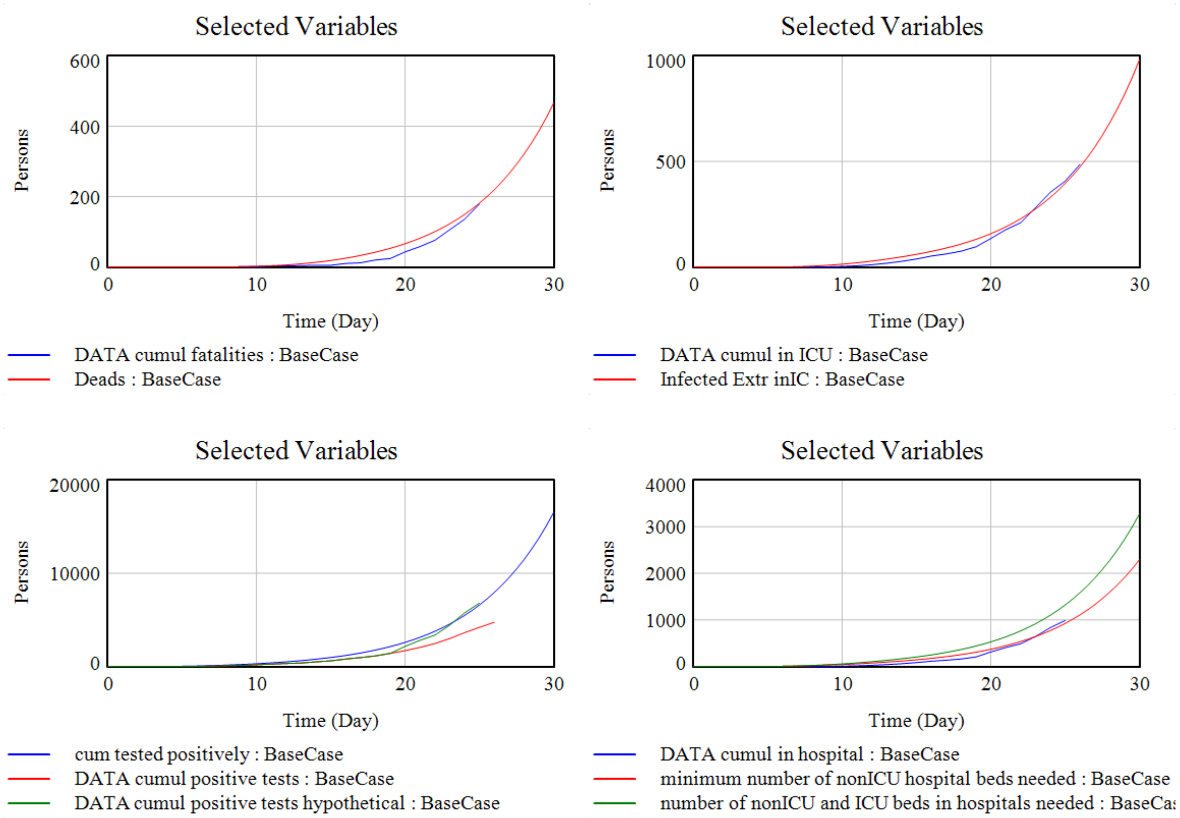

Figure 3: BaseCase simulation run compared to real data

5. Results: From Base Simulation to Social Distancing

a. BaseCase

We could investigate many things with our model. We will leave that for future investigations (with a more detailed version of the model with age cohorts, with different geospatial scales as well as the international context, and by simulating it under deep uncertainty). Here we will simply look at a few simulation runs related to social distancing. Because it is so important at this point in time.

The reason why we are publishing these results now (instead of waiting for more refined results), is that it is absolutely necessary for anyone in the country to take the social distancing advice by the ministry and health service seriously. The results of these simulations might be shocking. Note that these results are only indicative and that many aspects (such as herd immunity at 60%-80% of the population) are not (yet) taken into account. For the sake of simplicity, asymptomatic infections (i.e., people who are infected but do not have any symptoms) are not included here either. This means that everybody who is infected gets at least mild symptoms. In future analyses, we will include asymptomatic infections.

Above we looked at the first 30 days of the epidemic in the Netherlands. Let’s look at a longer time period. Without any social distancing measures (be it government imposed or self imposed), in this simple version of the model, the entire population of 17.7 million persons would be infected within a period of about 75 days from day 0 (see “from exposed to asymptpmatic infected” – asymptomatic here refers to the stage before the onset of symptoms). Within 100 days from day 0, most people would have recovered or died, except for those in Intensive Care Units (ICUs) who need more time to recover. Note also that in this model, ICU increases to 1800+ beds ("Infected Extr inIC"). However, if we would get that rapid a peak of infections, then one of the biggest problems would be the shortage of beds in ICUs. The right side graph in Figure 4 ("Infected Extr nexttoIC"), shows the number of Infected individuals with Extreme symptoms (like double pneumonia) who need to be in ICU but are not in the absence of free ICUs upon their arrival. Many of them would die.

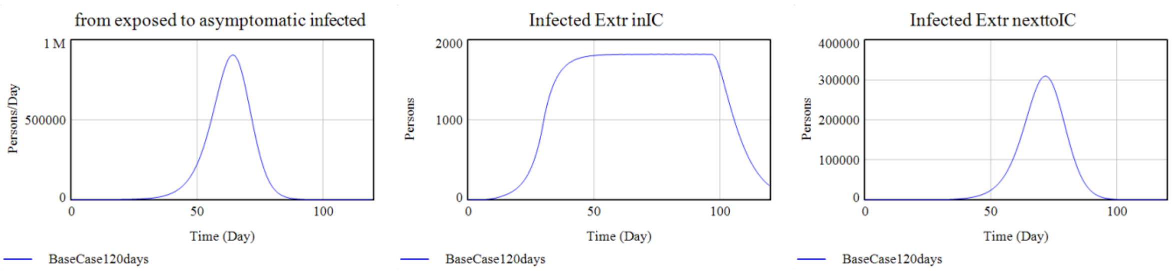

Figure 4: Infections (left), Infected with Extreme symptoms in Intensive Care (middle), Infected with Extreme symptoms who want to go to Intensive Care but cannot due to limited capacity (right)

We deliberately do not show graphs of the COVID19 deaths, since we need to be careful with numbers about fatalities. We will use the multi- cohort version of the model to say something about deaths. What should be clear – even without graphs depicting the number of deaths – is: our health system cannot possibly handle this basecase situation. Not at all. This is why, in the absence of vaccines, social distancing is absolutely necessary.

b. Social Distancing

Let's investigate whether social distancing could make big enough a difference or not. Figure 5 shows the effect of contact rate reduction with 0% (i.e., the BaseCase), 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80% and 90% starting on day 25 on the underlying infections that are taking place (which do not immediately show in the real world). Any contact rate reduction up to 70% only flattens the peak.

Figure 6 (which is a zoomed in version of Figure 5) shows that there is not much difference between a contact rate reduction of 80% and 90%, at least not in terms of a peak in infections, because in those cases we are not flattening the curve – there is no noticeable curve.

Note, however, that there is a substantial difference with the 70% contact rate reduction. 70% contact rate reduction would flatten the curve, but it seriously affect the health system.

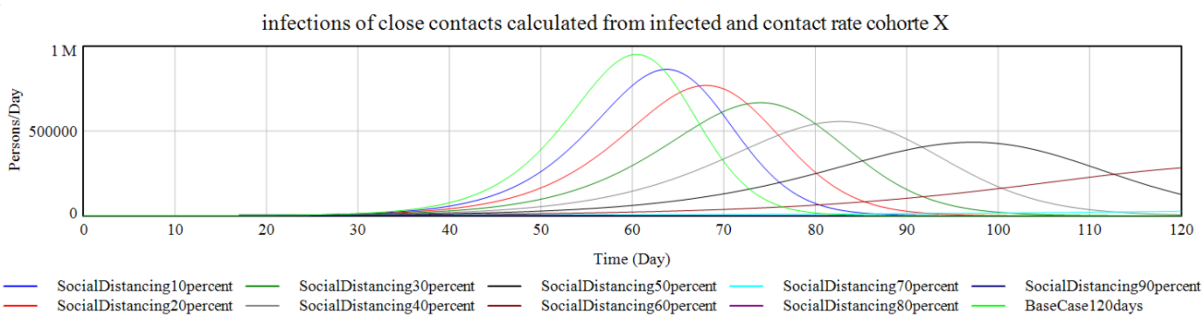

Figure 5: effect of contact rate reduction from day 25 on with 0% to 90% on infections (invisible then)

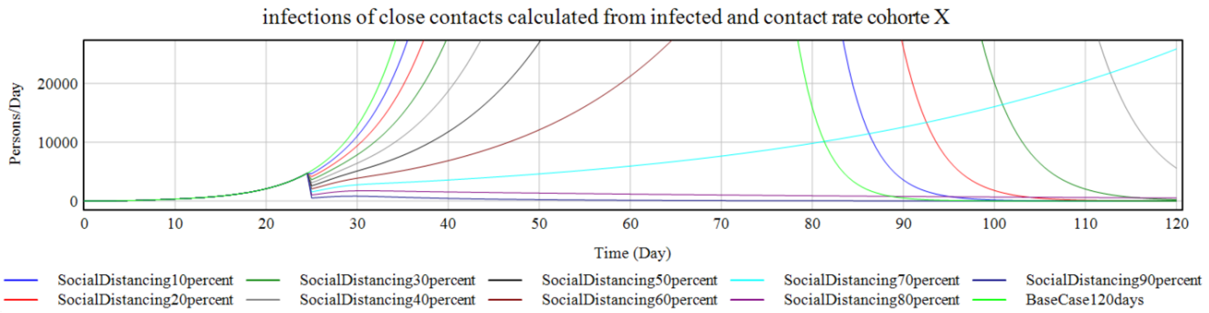

Figure 6: detail of Figure 5 (contact rate reduction from day 25 on with 0% to 90% on infections)

Figure 7 shows what social distancing with a contact rate reduction of 90% means in terms of ICU capacity: In case of extreme contact rate reduction, ICU capacity will still need to ramp up close to the maximum manageable level soon (some 1500 units, or all ICU plus part of the operating rooms), while social distancing with a contact rate reduction of 80% means that ICU capacity will need to ramp up to higher levels but also that it will be needed much longer at much higher levels. Social distancing with a contact rate reduction of 70% means that soon all ICU units would be needed for a very long time. Moreover, many people who need access to ICU capacity would not be able to get access at all. Figure 8 shows the effects in terms of people that need to be taken care of outside of ICUs – with a number of casualties that is a multiple of the 80% and 90% contact rate reductions.

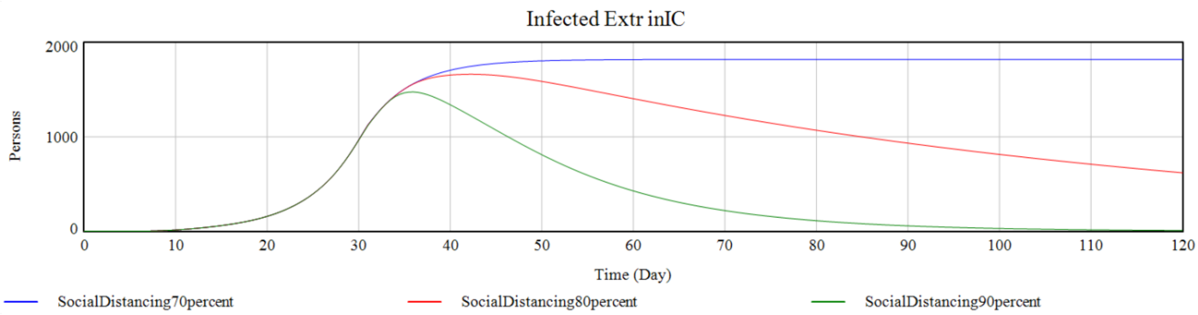

Figure 7: effect of a contact rate reduction from day 25 on of 70% to 90% on ICU capacity

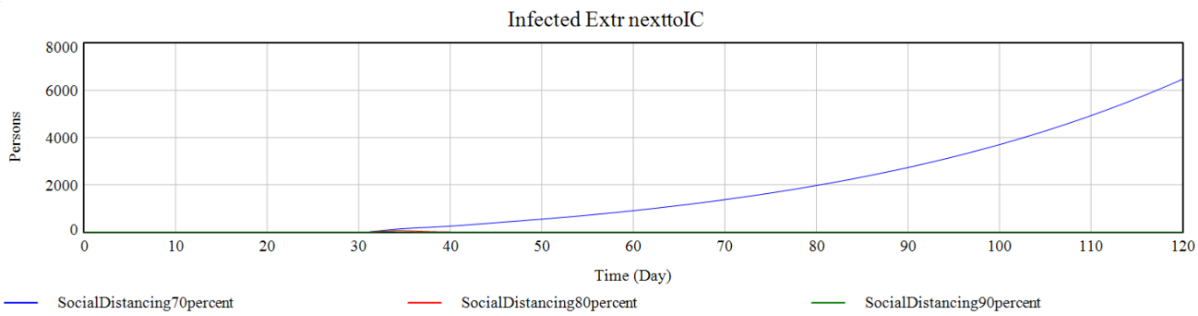

Figure 8: effect of a contact rate reduction from day 25 on of 70% to 90% on lacking ICU capacity

Figure 9 shows the cumulative number of COVID19 deaths, but only for the 70%, 80%, and 90% contact rate reductions. Note that the latter calculations really require a model with age cohorts (future work).

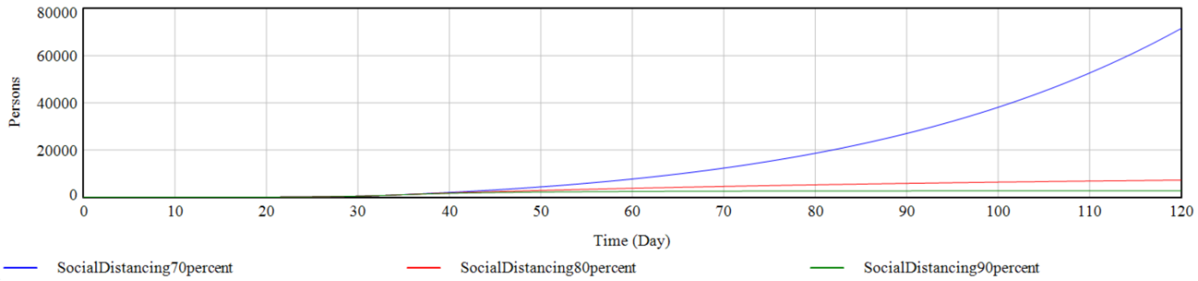

Figure 9: effect of a contact rate reduction from day 25 on of 70% to 90% (and of lacking ICU capacity) on COVID19 fatalities [indicative at most, since we need to use a cohorte model for this]

In this simple version of the model, the 2700+ deaths that follow a contact rate reduction of 90% and the 7000+ deaths that follow a contact rate reduction of 80% from day 25 on are in sharp contrast to the number of deaths of any stratagy to flatten the curve.

c. Delayed Implementation or Response

Any delay before this sharp contact rate reduction happens, leads to a situation that is harder to handle. Figure 10 shows the effect of an 80% contact rate reduction going into effect at different moments in time: day 25 (23 March 2020), day30 (28 March 2020), day 35 (2 April), and day 40.

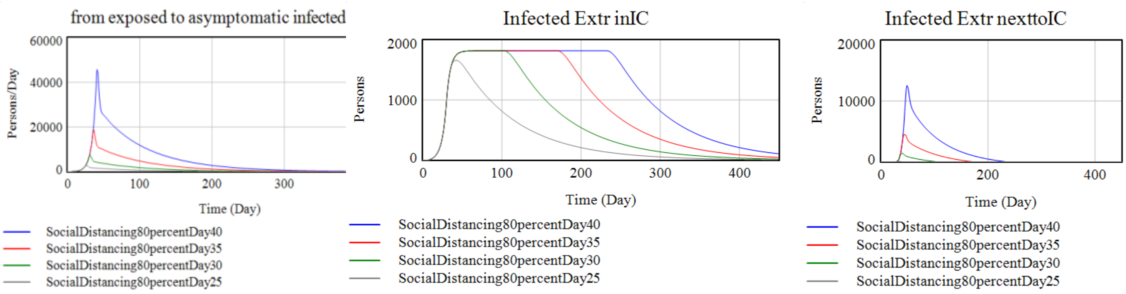

Figure 10: Effects of delayed implementation of social distancing

Longer delays before strong social distancing is introduced, translates right away into more people in need of ICU who do not have access since all ICU capacity is occupied. Since patients with extreme symptoms really need ICU and ventilators, this mean that there will be a strong effect in terms of COVID19 deaths too. Every 5 days delay results in a 3 fold increase in the number of COVID19 deaths.

d. What about the duration of strong social distancing measures?

Although an answer to this question requires an international model (i.e., a model with all countries in the world) and preferrably an Agent Based Model (for contact tracing), let's reason about the time it takes to get a grip on COVID19. Since both strong social distancing measures in the model control the virus, but do not eradicate it, it will resurge the moment social distancing is relaxed unless contact tracing and local measures can contain any starting outbreak. But a lockdown or strong social distancing would at least need to last the incubation time (say 14 days) plus the time of an infection with mild symptoms (say 7 days) plus the time the virus can survive on materials (say 17 days). In other words, some 40 days. And that is only so if anyone with heavy and extreme symptoms remains in isolation for as long as he or she is contagious.

6. Discussion / Conclusions / Advice

It should be clear to anyone reading this note that sufficiently strong social distancing measures are needed for dealing rapidly with this outbreak, both in terms of ICU capacity and fatalities. Social distancing that is enough to flatten the curve might lead to quite an impact on ICUs and deaths.

Another consequence of social distancing focussed on flattening the curve, is the duration of the outbreak. Social distancing of 70%, at least in this model, would mean COVID19 would be with us for about a year (even longer if long term recovery in ICU is taking into account).

Social distancing merely enough to flatten the curve would lead to herd immunity. While this is true, it only does so after a relatively long period of time, during which the Netherlands will be a thread to any country that succeeded in nipping the epidemic in the butt or any country without infections. It might take as long as waiting for a vaccine and massively rolling out a COVID19 vaccination program.

Does this mean a total lock down? Not necessarily. If the population is disciplined enough, then a total lock down is not necessary. However, if people do not understand and do not comply, then there is no other way. Knowing this, we believe the Dutch population should be willing and able to reduce their contact rate enough. Else stronger measures are necessary, as soon as possible.

7. Future Work and Sponsors Needed

Our site (www.peas.center) will soon (asap) feature updates and reassesments. Our plan of action (if we have sponsors or clients, we might change the order of tasks or change our focus) is:

- To develop simulation results for multiple cohorts. These results are more suitable for assessing ICU capacity needs and hospital capacity needs, as well as fatalities.
- Simulate results for the Netherlands under deep uncertainty (both with our 1 population model and with our multi-cohort model)
- Simulate the situation in other countries under deep uncertainty (both with our 1 population model and with our multi-cohort model)
- Extend the model to include all countries in the world to assess the effects of countries in the international context.
- Extend the country model with the sub-national scales (provinces and municipalities) to provide help to majors, first for the Netherlands, possibly for other countries.

We do not have a client or sponsor for this line of work. Any specific question or investigations requires a lot of work and expertise. We are ***not*** paid by academia nor any other COVID19 related organisation. In order to be able to free up time and resources, we need sponsors or clients. We are ready, willing, and able to provide advice to governments, “veiligheidsregios”, majors, NGOs in need of COVID19 advice. Contact for prospective clients and sponsors: info@peas.center .