Swiss Versus-Virus Hackathon

Challenge #146 : “Let's use decentralisation to shield our people at risk”

“PROOF OF CONCEPT” for protecting citizens at risk during and after the SARS-COV-2 outbreak and epidemic.

Presentation

In this document, we show why scaling the measures proposed by the team **the yellow cape* (see the document “Social Code and Measures”) to the entire Swiss population will save thousands of lives!

We model the evolution of COVID-19 in Switzerland with a model similar to the ones developed and currently used by epidemiologists all over the world. We estimate the size of the population at risk - and their risk - to predict the effect of using the yellow cape technique in Switzerland.

Conclusion

Our epidemiological model is as powerful as the state-of-the-art models used in academia and by response teams. It predicts that the government actions more than halved the propagation speed of the virus, but not enough to prevent it from spreading. **Social distancing is a very effective tool to fight COVID-19.**

We consider that by implementing the yellow cape method, the risk that people at risk contract the disease goes down by about 25% thanks to everyone making sure they are not exposed. Even if people who are not at risk have a slightly higher risk of catching the disease, this change leads to less people being infected overall. The yellow color acts as a reminder to help people get in the habit of maintaining social distances.

The biggest benefit is on the total number of deaths: **by implementing the yellow cape, we can reduce the total number of deaths by at least 20% more and save thousands of lives!**

Estimating the pool of people at risk

We based the following statistics on data provided by the Swiss government and the Versus Virus hackathon. The Swiss population is approximately 8.57 million people.

Group one: older people

Demographically, 18.5% of the Swiss population is 65 years old or older. It is important to remark that seniors would not necessarily need to wear one of the items within our identifying strategy, it is their personal choice to use and wear them. Nevertheless, they would benefit directly from the measures and derived benefits.

Parents living with at least one of their children, who is 25 years old or older, in 104'929 households. Single parents also live with at least one child, who is 25 years old or older, in 58'971 households. Swiss households have an average 2.26 people.

The distribution of parents having a kid of 25y/o or older is for adults between 43 and 82 years old.

- Estimating that 66% of this households are composed by 25y/o + sons living with one or two parents, parents have 65 years or less: 104929 households*0.33 percentage living with 65+*(2.26-1) people per household = 43629 people // or 104929*0.33*2 = 69253.
- Same exercise for households of 1 parent: 58971*0.33*(2.26-1) = 24520 people // or 58971*0.33*1 = 19460
- Total on this chapter: between 68149 people and 88713 people

Group two: people with pre-existing medical conditions

- Cancer: 95355 citizens

In Switzerland, 317 000 people live with a cancer diagnosis. Of which, people who have been diagnosed with cancer for more than 5 years (200 000) are considered as healed. This leaves an approximate headcount of 117 000 people with cancer : that's 1,28%*of Switzerland's population. (2015, source: OFSP).

As stated before, the population over 65+ y/o is 18.5% of the total. Considering this, we obtain a number of 95355 people under 65 years.

- Cardio-vascular disease and arterial hypertension: 555912 citizens

Considering the shape and the data of the swiss demographic pyramid. The info obtained from the swiss "enquete de la sante" we obtain a number of citizens suffering from this disease of 555912. This number gives out 344098 men and 211819 women under 65 years.

- Chronic respiratory diseases: 289054 citizens

Considering the shape and the data of the swiss demographic pyramid. The info obtained from the swiss source we obtain a number of citizens under 65 y/o suffering from this disease of 289054.

- Diabetes: 155361 citizens

Considering the shape and the data of the demographic pyramid. The info obtained from the swiss "enquete de la sante" we obtain a number of citizens under 65 y/o suffering from this disease of 155361.

Group three: pregnant women

"Currently available data on COVID-19 does not indicate that pregnant women are at increased risk. However, pregnant women are known to be at greater risk of severe morbidity and mortality from other respiratory infections such as influenza and SARS-CoV. As such, pregnant women should be considered an at-risk population for COVID-19" (source). Giving out a counting of 88000 women.

That is a total of 1.58M + 1.28M = 2.84 millions citizens

In total, about 2.84 millions citizens, representing 20 to 33% of the total Swiss population, will benefit from the yellow cape technique

Death rate and comorbidities of the risk group citizens.

As another input to our model and estimations, the overall death rate and the averaged death rate due to SARS-COV-2 when existing medical conditions were already present have been obtained from different sources available online.

The values obtained were averaged and the following figures were extracted:

- Patients who reported no pre-existing medical conditions have a fatality rate of 0.9%
- Patients who reported previous existing medical conditions: in average a fatality rate of 7.3%. Meaning this, we have considered that the chances of dying are 8.1 times higher for a citizen with a pre-existing medical condition.

Pre-existing condition	Death rate (confirmed cases)	Death rate (all cases)
Cancer	7.6%	5.6%
Hypertension	8.4%	6%
Chronic respiratory disease	8.0%	6.3%
Diabetes	9.2%	7.3%
Cardiovascular disease	13.2%	10.5%

Modeling the effect of protective measures

Epidemiologists use a model called SIR that estimates the number of people Susceptible to the disease (S), currently Infected (I) and who Recovered (R) of the total population (N) and predicts the propagation of a disease. The results of the model give us the famous basic reproduction number R_0. A value of R_0 above 1 means more and more people are infected. Epidemiologists sometimes included the number of Deaths (D).

Our analysis initial implement a model very recently published[1] in the literature to predict the true propagation of COVID-19 in France. We add the total number of deaths and integrate the following differential equations:

$$S' = -\alpha S I / N$$

$$I' = \alpha S I / N - \beta I - \gamma_d I$$

$$R' = \beta I$$

$$D' = \gamma_d I$$

where α describes how contagious the disease is, β describes how many people heal from it and N is the population of the country we consider. The basic reproduction number R_0 is equal to α/β. The French model finds[2] values of $\alpha = 0.24$, $\beta = 1/20$, a mortality rate $\gamma_d = 5.2/1000$ and $R_0 = 4.8$! The value of R_0 is high, but the data used goes up to March 17 in France, before the confinement has had effect.

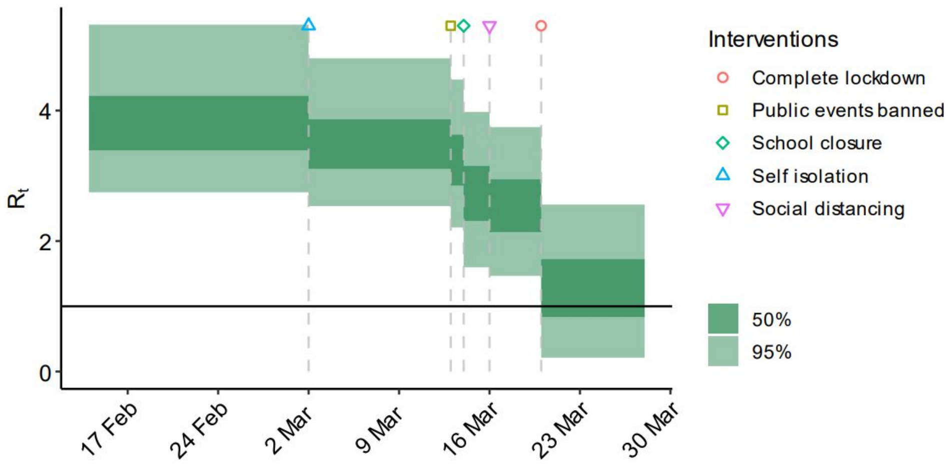
The Swiss data however reflects several decisions taken by the country in the last few weeks: they progressively closed off borders more and more strictly, they stopped large manifestations then small ones and they eventually closed schools and non-essential shops. Finally, on March 20, they forbade all meetings of more than 5 people as an alternative to the strict confinement currently ongoing in France, Italy, Belgium or Spain. Each of these decisions changed our society, R_0 and the propagation of the virus.

We included this information in our model, and adapted R_0 six days after each significant measure is taken. The delay reflects what researchers are inferring from cases throughout the world: some confirmed cases are already contagious before they show symptoms and are tested, so our numbers lag behind. We test values of R_0 to find the ones that best fit the number of confirmed cases published by Switzerland[3].

[1] Roques, L., Klein, E., Papaix, J., & Soubeyrand, S. (2020). Mechanistic-statistical SIR modelling for early estimation of the actual number of cases and mortality rate from COVID-19. *arXiv preprint arXiv:2003.10720*.
[2] The value of ⍰ comes from Zhou et al. (2020).
[3] Our numbers are based on data scraped by the Johns Hopkins University and by Daniel Probst.

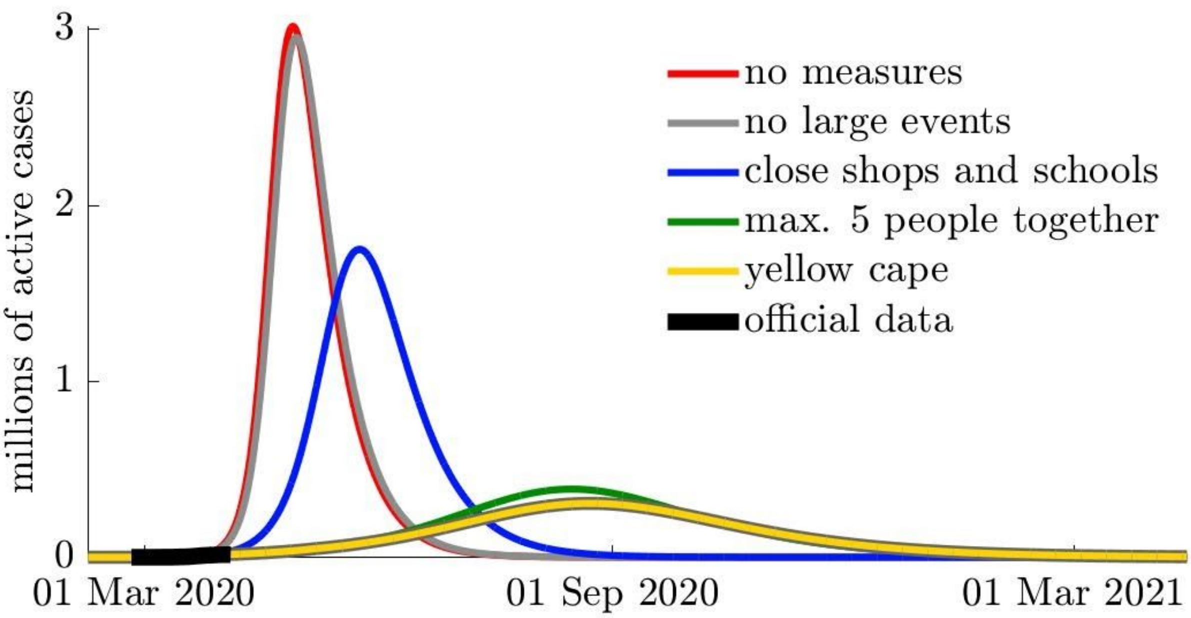
We find $R_0 = 3.5$ before Switzerland took any large scales measures. On February 28, the country decided to cancel all large manifestations (notably Carnival) and to loosen quarantine conditions, R_0 lowered slightly to 3.45, subsequent measures (progressive closing of the border and cancelling events with more than 100 people) had a limited effect on the propagation. On March 16, the country took the unprecedented step of closing schools, non-essential shops and of asking everyone to work from home. On March 20, they strengthened their measures by forbidding all meetings of more than 5 people. R_0 dropped to 2.36 and is now at 1.43! **The government actions more than halved the propagation speed of the virus, but not enough to prevent it from spreading.**

These values, obtained with our model, perfectly match the values obtained by the COVID-19 Response Team of the Imperial College:



We can conclude the following: **our epidemiological model is as powerful as the state-of-the-art models currently published in the literature and used by response teams.**

In particular, we can show the effect of the successive measures on the epidemic curve of people confirmed positive to COVID-19 and sick. Reducing transmission of the virus leads to the now famous flattening of the curve effect, but it also means we need to enforce the measures for a longer time to protect our people. **The main advantage of flattening the curve is to ensure that everyone can get medical care at hospitals, and to lower the overall number of deaths** (we show the effect of flattening the curve on the number of deaths later in this document). We can also show the effect of the yellow cape measures on the epidemic curve:



Modeling the effect of the yellow cape

For the simulations, we estimated that 31% of the Swiss population is at risk. 18.5% of the population is above 65 years old, 12.5% is below 65 years old but suffers from cancer, diabetes, cardio-vascular diseases, hypertension or chronic respiratory diseases. We also estimate that people at risk are 8.1 times[4] more likely to die from COVID-19 than people not at risk.

We use the same SIR model as before, but instead we consider two populations (31% of people at risk and 69% not at risk, with their respective mortality rate). If the yellow cape solution is not implemented, the contage risk remains the same for everyone and the pandemia progresses the same.

However, if we consider that people at risk and their close peers start wearing yellow markers, we can estimate that their basic reproduction number R_0 goes down by 25% thanks to everyone making sure they stay safe and are not exposed[5]. The population not at risk might

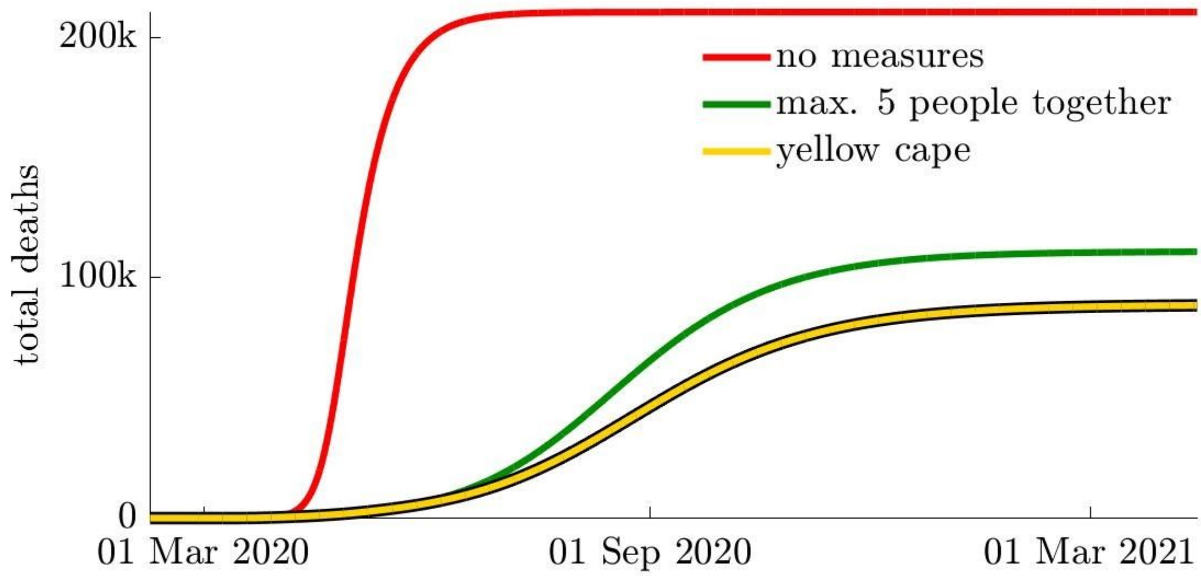
[4] WHO-China and the Chinese Center for Disease Control and Prevention estimated these risks with similar orders of magnitude. We however tailored the mortality rate of the groups at risk and not at risk so that the overall number of infected people and deaths would remain the same when considering the French overall mortality rate of 5.2/1000 and our yellow cape model with two distinct groups. This way we maintain realistic results for the Swiss population.

[5] This number is an educated guess that accounts for the reduced number of contacts for people at risk in public spaces (in particular on the streets and in shops). People living closely with them also wear the yellow vest and lower the risks of those they protect as well.

then be slightly more exposed so we estimated that their R_0 goes up by 5%[6]. Overall, this change leads to less people being infected (see the yellow curve on the previous figure).

The biggest benefit is however on the total number of deaths, when the propagation speed is lower, a smaller fraction of the population is infected at the end of the pandemia, and less people die. Social distance helps, but so does **specifically maintaining social distance with people who are at risk**. The measures from the government reduce the expected number of deaths by 47%. **By implementing the yellow cape, we can reduce the total number of deaths by at least 20% more and save thousands of lives!**

The result is visible on the figure below, that shows the total number of deaths. If the virus spreads rapidly, a higher percentage of the total population becomes sick, more people at risk become sick and die. This is why it is so important to reduce propagation and help people who are at risk.



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[6] Let's say a person who is not at risk has to choose between two sidewalks or two seats on a train, one where she will be close to a person wearing yellow and one where she will be close to a person not at risk. She will choose to get close to the person who is also not at risk. As a result, people not at risk might be slightly more likely to get sick (but since only a minority of people are at risk, this increase is small). We also expect yellow to be a good reminder to keep social distance, and to help people master it.