THE IMPORTANCE OF THE INTERPLAY BETWEEN SUBCRITICAL FLUCTUATIONS AND IMPORT IN UNDERSTANDING THE DYNAMICS OF COVID-19 EPIDEMIOLOGY

Nico Stollenwerk*1,2, Maira Aguiar1,2,3
1BCAM, Bilbao, Spain
2University of Trento, Trento, Italy
3Ikerbasque, Basque Foundation for Science, Bilbao, Spain
nico.biomath@gmail.com (*presenter), maguiar@bcamath.org

In models which could describe the first wave of COVID-19 and its control during the lockdown phase [1, 2, 4] we now investigate the role of large fluctuations in the controlled but only slightly subthreshold system since the lifting of the lockdown, which is characterized by increased mobility but still under restrictions like wearing masks and social distancing. For a detailed account of such large fluctuations around critical thresholds in epidemiology see [5]. The lifting of the lockdown in summer 2020 led to an increase of the infection rate with growth factors and momentary reproduction ratios hovering around the epidemic threshold (of decrease to extinction versus exponential growth). The interplay of import and sub-threshold community spreading can explain this dynamical behaviour of hovering around threshold by the expected large stochastic fluctuations. Subthreshold community spreading leads to a decline in cases, and a small import renews isolated outbreaks with long tail small and occasional large sizes, which can lead to a stationary number of new cases in mean field approximation, still with the large fluctuations around it. Such increased number of cases with occasionally large outbreaks looks to many people like a "second wave of COVID-19", but we would like to reserve this term to new exponential growths with supercritical dynamics potentially much larger than the subcritical dynamics with import. This explains the dynamic behaviour of the data on COVID-19 observed in the Basque country at least until end of October and beginning of November 2020, too often already called a "second wave" comparable with the first wave of exponential growths in March and April 2020 where community spreading was definitely well above the critical threshold. No such supercritical exponential growth was observed in the number of cases from August to November 2020.

We first describe the interplay between critical fluctuations and import in simple models of SIS and SIR type, taking previous results on directed percolation [9, 8] and dynamical percolation [6, 7] in such epidemiological systems into account, before generalizing to the SHARUCD modeling framework relevant for a more detailed analysis of the present COVID-19 epidemiological data.

The import ϱ was already taken into the modelling approach during the first wave but the initial explosive exponential growths and then the complete lockdown hindered to large extend any information on this from the empirical data. Now during the lockdown-lifting phase in summer/autumn 2020 the import has become essential in understanding the dynamics in combination with ε = β - γ ≈ 0, the sub-threshold community
spreading, whereas an already new "second wave" would lead with $\varepsilon >> 0$ to a new exponential growth, which is only to be expected later during the year, namely in the onset of the respiratory disease season with increasing community spreading $\beta(t)$. In the Basque country this would be only in late November or early December as past years’ influenza data suggest, of course subject to fluctuating climatic circumstances.

The analysis is mainly based on the development of severe cases, i.e. hospitalizations, intensive care unit admissions and deceased cases, while the total number of positive cases with COVID-19 is largely due to changes in testing capacities. During the first wave only symptomatic/clinical cases were tested, and even there with low positivity rate, while during summer the testing capacities increased to an extend that at some times more than 80% of detected cases were asymptomatic or mild/subclinical, this also changing the case fatality ratio from initially very high values to more moderate values now [3], this in all countries where previously large differences between countries were reported.

Acknowledgements

This work has received funding from the European Unions Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 792494.

References

https://doi.org/10.1038/s41598-020-74386-1.

https://doi.org/10.1371/journal.pone.0236620.

https://doi.org/10.1016/j.puhe.2020.08.021

http://journals.itb.ac.id/index.php/cbms/article/view/14123


