

# Local collective immunity leads to periodic epidemic outbursts

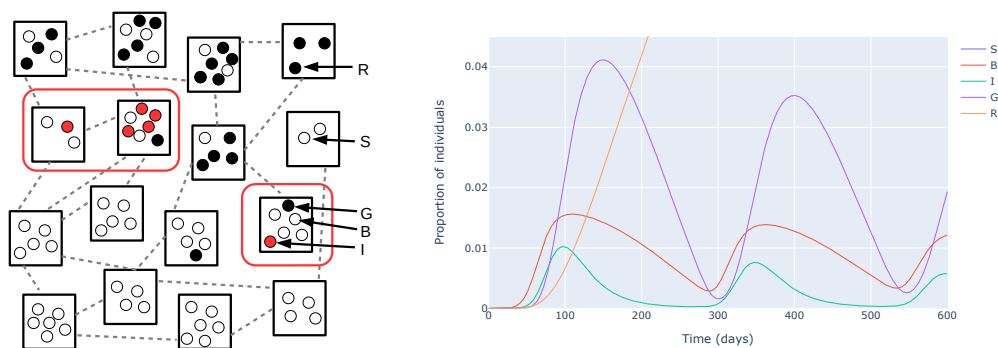
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Mathematical models of epidemics remain indispensable in the fight against diseases such as the COVID-19 crisis. Simple mathematical models help to take political decisions such as mobility restrictions. The compartmental SIR model is the paradigm-model to illustrate the elementary dynamics of epidemic spreading in a well-mixed community. It is too simple to describe the dynamics of a realistic epidemic, in particular since no distinction is made between susceptible individuals which are in contact, or on the contrary, far away from infectious individuals.

We showed recently [1] that this well-mixedness assumption can be leveraged by dividing the community into individuals close to, and those far away from the infected. The so-obtained SBIR model, where the B-compartment represents the susceptible individuals surrounding the infected, allowed to reproduce both the rapid initial increase and exponential decay of the number of new infections in a number of countries where strict lock-down measures were imposed.

At longer times, the population also contains recovered individuals far away from the infected and this should be taken into account in a model which aims at representing the long-time evolution of an epidemic. The minimal model is then the SBIGR-model (Fig. 1(a)), which reproduces the quasi-cyclic outbursts (Fig. 1(b)), as observed in the influenza and COVID19 pandemia.



**Figure 1.** (a) Schematic of the interactions in a population. Square boxes regroup individuals who closely interact, as in households or in professional context. The ensemble of these micro-communities which contain at least one infected individual are defined as "the blob" (denoted by the red contour), and the associated individuals are indicated by  $B, I, G$ . Susceptible or removed individuals outside the blob are indicated by  $S, R$ , respectively. The grey lines indicate spatial interactions between micro-communities (meeting through public transport or in crowded shopping centers). (b) Numerical integration of the SBIGR model reproduces quasi-periodic bursts.

## References

1. BOS, WOUTER JT AND BERTOGGIO, JEAN-PIERRE AND GOSTIAUX, LOUIS, *Computational Mechanics*, **67**, 1485, (2021)