The source of individual heterogeneity shapes infectious disease outbreaks

Baptiste Elie, Christian Selinger, Samuel Alizon

MIVEGEC, Université Montpellier CNRS IRD

Infectious disease transmission patterns in some outbreaks can be more heterogeneous than in others, with striking effects on the way epidemics unfold. Some studies show that the biological sources of heterogeneity may matter, but they tend to do so without controlling for the overall heterogeneity in the number of secondary cases caused by an infection. Here, we control for this important bias to explore the role of individual variation in infection duration and transmission rate on parasite emergence and spread. We simulate outbreaks using a stochastic SIR model, with and without parasite evolution. Consistently with existing studies, we show that the variance in the number of secondary infections has the strongest effect on outbreak emergence probability but has little effect on the epidemic dynamic once emergence is certain. The origin of heterogeneity also affects the probability of emergence, but its more striking effects are about properties of epidemics that do emerge. In particular, assuming more realistic variances in infection duration distributions lead to faster outbreaks and a higher peak of incidence. When the parasite requires evolutionary changes to be able to spread, the impact of heterogeneity depends on the underlying evolutionary model. If the parasite evolves within the host, decreasing the infection duration variance decreases the probability of emergence. These results show that using realistic distributions for infection duration is necessary to accurately capture the effect of individual heterogeneity on epidemiological dynamics, which has implications for the monitoring and control of infectious diseases, as well as data collection.

1. What is your pathogen? Multiple options possible (e.g. if working on coinfections)

Other : theoretical epidemic spread - no specific disease

2. On a scale of 1-5 is your work mostly eco/epidemiological or evolutionary? 2

3. On a scale of 1-5 is your work mostly theoretical or experimental/empirical?

1 (100% theoretical or experimental)