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Analysing the Effect of Test-and-Trace Strategy in an SIR Epidemic Model

Dongni Zhang and Tom Britton

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Abstract

Consider a Markovian SIR epidemic model in a homogeneous community. To this model we add a rate at which individuals are tested, and once an infectious individual tests positive it is isolated and each of their contacts are traced and tested independently with some fixed probability. If such a traced individual tests positive it is isolated, and the contact tracing is iterated. This model is analysed using large population approximations, both for the early stage of the epidemic when the "to-be-traced components" of the epidemic behaves like a branching process, and for the main stage of the epidemic where the process of to-be-traced components converges to a deterministic process defined by a system of differential equations. These approximations are used to quantify the effect of testing and of contact tracing on the effective reproduction numbers (for the components as well as for the individuals), the probability of a major outbreak, and the final fraction getting infected. Using numerical illustrations when rates of infection and natural recovery are fixed, it is shown that Test-and-Trace strategy is effective in reducing the reproduction number. Surprisingly, the reproduction number for the branching process of components is not monotonically decreasing in the tracing probability, but the individual reproduction number is conjectured to be monotonic as expected. Further, in the situation where individuals also self-report for testing, the tracing probability is more influential than the screening rate (measured by the fraction infected being screened).