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The impact of threshold decision mechanisms of collective behaviour on disease spread

Humans are a hyper social species, which greatly impacts the spread of infectious diseases. How do social dynamics impact epidemiology? How does public health policy best take into account these impacts? Here we develop a model of disease transmission that incorporates human behaviour and social dynamics. We use a "tipping-point" dynamic, previously used in the sociological literature, where individuals adopt a behaviour given a sufficient frequency of the behaviour in the population. The thresholds at which individuals adopt behaviours is modulated by the perceived risks of infection, i.e. the disease prevalence and transmission rate, and the behaviour of others. Social conformity creates a type of "stickiness" whereby individuals are resistant to changing their behaviour due to the population's inertia. In this model, the epidemic attack rate is sensitive to the timing of the behavioural response. Near the optimal response, small errors can result in large increases in the total number infected during the epidemic. And, more surprisingly, we observe a non-monotinicity in the attack rate as a function of various biological and social parameters such as the transmission rate, efficacy of social distancing, the costs to social distancing, the weight of social consequences of shirking the norm, and the degree of heterogeneity in the population.