Vaccination behavior and the evolution of virulence

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Evolutionary epidemiology predicts that vaccination can shape pathogen virulence (that is, pathogen-induced mortality) by altering selective pressures on pathogens. Yet most evolutionary models rely on an oversimplified representation of host behavior, assuming a fixed fraction of vaccinated individuals throughout an epidemic. In reality, vaccination decisions are dynamic and respond to epidemiological conditions and social influences, thereby modifying pathogen evolutionary dynamics. To capture this bidirectional feedback, we develop a framework integrating evolutionary and behavioral epidemiology. Epidemic dynamics are described using a model of ordinary differential equations with vaccination at birth, virulence evolution is tracked through a quantitative genetics approach, and behavioral changes are modeled using imitation dynamics. We compare this framework to a baseline scenario with fixed vaccination uptake and also explore how the speed of virulence evolution influences epidemic dynamics. Behavioral dynamics generate recurrent epidemic outbreaks and cyclical changes in virulence, leading to repeated mortality peaks. Under certain conditions, vaccination dynamics can transiently produce higher mortality than scenarios without behavioral change. The speed of virulence evolution further affects the occurrence, period, and amplitude of outbreaks. Together, our results highlight the importance of accounting for feedbacks between human behavior and pathogen evolution when informing public health decision-making.

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