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Modeling the waning and boosting of immunity: A case study of pertussis in Sweden

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Abstract

Pertussis, commonly known as whooping cough, is caused by the bacterial pathogen *Bordetella pertussis*. Completely susceptible individuals experience severe disease, with the hallmark cough, but those with partial immunity have milder if any symptoms. Immunity following natural infection or immunization may wane, increasing susceptibility with time since infection or vaccination. The age-specificity of contacts and population immunity likely influence the risk and dynamics of infection. We developed an age- and immune status-dependent model of pertussis transmission. Susceptibility, infectiousness, and symptom severity all vary with immune status, while age affects contacts and vaccination. Under the assumption of proportionate mixing, we derived an expression for the basic reproductive number, R_0. Using demographic and vaccination data from Sweden and contact data from Europe, we simulated the impact of primary vaccination and two booster doses. In our model, vaccination leads to a resurgence of immunity-modified pertussis in older children, as observed with effective vaccination programs elsewhere. In Sweden, these effects were mitigated by timely re-vaccination of schoolchildren and adolescents. With data from other locations, our model may assist in the development and optimization of vaccination schedules for pertussis.