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A Tale of Two Incidence Functions: How Post-Infection Effects Shape Disease Dynamics

In epidemiological modeling, mass-action and standard incidence are two fundamental formulations of disease transmission. The former assumes a constant per-capita contact rate that scales with population size, while the latter accounts for limited contacts by normalizing the transmission term. Although both often produce similar long-term dynamics, their differences become pronounced when complex biological mechanisms are included.

In this study, we analyze a compartmental model incorporating post-infection mortality and partial immunity to compare these two incidence forms. For the mass-action model, bifurcation analysis reveals possible periodic outbreaks under certain parameter regimes, whereas the standard incidence model tends to suppress oscillations, leading to stable endemic equilibria. When infections persist, both analytical and numerical results show that endemic levels can remain low before rising sharply as transmission increases. These results highlight how incidence structure and reinfection jointly shape disease dynamics and have important implications for modeling long-term pathogen persistence in host populations.