

Rich epidemiological dynamics due to the waning and boosting of immunity

Gergely Röst

HCEMM / University of Szeged

Immunity following natural infection or immunization may wane, increasing susceptibility to infection with time since infection or vaccination. Immunity can also be boosted upon re-exposure or re-vaccination. To capture the interaction of these epidemiological and immunological phenomena, we can formulate mathematical models in terms of partial differential equations, integral equations, delay differential equations, or ordinary differential equations. In this talk, we explore the relationship between these formalisms, depending on the mechanism of boosting. Combining analytical and some recently developed numerical tools, we uncover very rich dynamics of such systems, with a range of possible abrupt changes including Hopf, saddle-node, period doubling and torus bifurcations. In a few scenarios we find multistability of limit cycles, and show that this can explain some unusual observed post-pandemic patterns of respiratory infections. Extending the models with age structure allows us to suggest vaccination strategies, which we illustrate with applications to pertussis and SARS-COV-2.

In Special Session 64 on Dynamics of Infectious Diseases: From Within-host to Population-level at the Mathematical Congress of the Americas 2025.