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An Epidemic Model with Age of Infection-Dependent Transmission Rate and Waning Immunity

The aim of this work is to provide a model for infectious agents with a transmission rate that varies during the infectious period, and/or that have the ability to reinfect a host.

Influenza is an example of a disease that satisfies both characteristics. The probability that an individual transmits influenza is directly related to the amount of virus shedding, which is linked to the time that has elapsed since the individual became infected (age of infection). The infectivity reaches its peak after 2-3 days then decreases until the person recovers. In addition to that, being infected with influenza completely protects the individual against reinfection by the same strain. But the virus mutates via the process known as drift, and new strains, against which the individual only has partial protection, appear in the population. Without the introduction of a completely new strain in the population (a shift process occurring) the immunity of a host to reinfection depends mainly on the amount of time that has elapsed since his last infection.

A nonlinear age of infection-dependent epidemiological model is proposed. Conditions for the existence, positivity, regularity and continuity of the solutions will be addressed. The analysis of the existence and stability of equilibrium solutions will be conducted using the theory of strongly continuous nonlinear semigroups. The model exhibits interesting outcomes, including the existence of multiple endemic equilibria, a backward bifurcation (i.e., the existence of a stable endemic equilibrium with $R_0 < 1$), and the existence of a stable endemic equilibrium even in the absence of vital dynamics.