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A two-stage SEIRS reinfection model with multiple endemic equilibria

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Since the introduction of SIR model by Kermack and McKendrick in 1927, compartmental models have been massively studied and successfully applied to various epidemic processes including characteristics such as quarantine, vaccination, variants, cross-immunity. Recently, a particular attention has been paid to reinfection models in epidemiology. To cite a few, threshold conditions for infection, reinfection and endemicity of various SIRS models are studied in [1], bifurcation analysis for a SIRI model presenting different contact rates for infection and reinfection in [2], and models counting reinfections in [3], [4].

Nevertheless, in most studies on reinfection, the infection and reinfection processes are assumed to behave essentially in the same way, which is quite limitative. With the aim of understanding the effects induced by differences between the stage of primo-infection and further reinfections, we introduce here an 8-dimensional two-stage SEIRS reinfection model in which the parameters characteristic of the disease dynamics are different for the primo-infection and for the following reinfections.

The value of the basic reproduction number $\mathcal{R}_0$ of the model around the (unique) disease-free equilibrium is first derived, and the existence of up to two and three endemic equilibria, respectively in the cases $\mathcal{R}_0 \leq 1$ and $\mathcal{R}_0 > 1$, is theoretically established under appropriate conditions on the system parameters. Finally, numerical testing and simulations are achieved, which in particular exhibit bistability in the cases when multiple endemic equilibria arise.

References

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