The impact of functional forms of the force of infection on the coexistence of two competing strains with complete cross-immunity in a population

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In the area of modeling infectious disease spread in a population, an important consideration is to select an appropriate functional form of the force of infection that is determined by transmission routes, either through close contact or through a contaminated environment. This study aimed to investigate the impacts of different functional forms of the force of infection on the coexistence of two competing strains of the same micro organism with complete cross-immunity in a population using a mathematical modeling approach. We constructed a simple compartmental model of two competing strains with complete cross-immunity and examined four types of functional forms of the force of infection including a linear form (assumed to act through close animal to animal contact), an exponential form (assumed to act through contact with a contaminated environment), and Holling's type II and III (also through a contaminated environment). The model was described by a system of nonlinear ordinary differential equations and was numerically solved for these four types of force of infection. The results demonstrate that coexistence of two competing strains with complete cross-immunity is possible for environment transmission even if their basic reproduction ratios are different and both basic reproduction ratios are greater than the threshold value of 1. It is important to note that for the conventionally used linear form of the force infection, only the strain with the larger basic reproduction ratio will eventually survive and co-existence is not an option. We explain our unusual results for coexistence of the two-strain competition model, and further discuss potential ranges of biologically relevant parameter values for two-strain coexistence in farm animal populations.