CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY

Name(s)
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Project Number
S1411

Project Title
The Effects of Superinfection on Virulence

Abstract

Objectives/Goals
Because superinfection has clinically been shown to have different effects under various conditions, this research project attempts to determine whether virulence of multiple strains on average increases or decreases and by what degree for selected initial conditions during superinfection.

Methods/Materials
A Java computer simulation, which consisted of a 20 x 20 grid of susceptible cells, was coded based on a combined mathematical model. One control group contained only an avirulent virus on a grid, and the other contained only a virulent virus. The baseline superinfection experimental group contained both viruses on the same grid. Three other test groups included superinfection but varied either initial virulence, competition factor, or mutation rate compared to the superinfection baseline group. Based on multiple simulation runs, the data from the controls and from test groups with different conditions were separately compared to those from the superinfection baseline group.

Results
The computer simulation suggested that both viruses limited each other in superinfection since the virulences and transmissions in the control groups were higher those in superinfection. Additionally, different conditions did impact virulence; lower initial virulence caused more variation in virulence, lower competitive asymmetry decreased virulence over time, and lower mutation rate led to quicker extinction of the virulent virus, greater leaps in average virulence, but more overall consistency in virulence.

Conclusions/Discussion
At almost all medium to high initial virulences for the virulent strain, the virus killed off cells too quickly, so virulence severely decreased. However, the virulence of the avirulent strain increased without causing its extinction, most likely because its transmission was above some threshold. The data suggest that virulence of one strain increases if initial transmission exceeds some threshold but decreases if below that threshold, especially with little competitive asymmetry, a high mutation rate, or an initial virulence that nearly maximizes the transmission.

Summary Statement
My computer simulation suggested that initial virulence, competitive asymmetry, and mutation rate help determine numerical outcomes of superinfection, but superinfection itself limits the virulence and transmission of all viruses involved.

Help Received
I received advice from Dr. Kara O#Keefe (UC Davis), Dr. Paul Turner (Yale), Dr. Jeroen Saeij (MIT), Dr. Ileana Cristea (Princeton), and Dr. Joshua Plotkin (U Penn).