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Quorum Sensing Interaction and the Effect of Antibiotic on the Dynamics of Two Types of Bacteria

Quorum sensing regulates bacterial population density through the production of signal molecules or to initiate biofilm formation, which increases resistance against antibiotics. When this process occurs, signal molecules are produced and released into the surroundings. Signal molecules induce some bacteria to produce even more signal molecules, a phenomenon known as autoinduction. Fast and slow growing strains of the same bacterial species were investigated, in which four ordinary differential equations were used to model the dynamics of these strains, antibiotic, and the signal molecule in the system. Only the fast-growing strain was capable of producing signal molecules. These molecules induce some of the fast-growing strain to convert to the slow-growing strain, which is more resistant to the antibiotic. Using numerical and analytical methods, equilibria and stability were analyzed with and without autoinduction. Three types of equilibrium can occur depending on parameter values. In one case, both of the bacterial strains were completely eliminated by the antibiotic, indicating a successful therapeutic treatment. In a second case, only the slow-growing strain survived, and in a third case both strains survived. Even though the first two cases can be stable, they may not be desirable since microbial organisms still exist, which can potentially lead to a chronic and persistent infection. When autoinduction was present, few differences were noted when compared to the data without autoinduction. However, autoinduction may still have effects on the dynamics when the antibiotic is dosed periodically or may have an impact on the duration of the infection.