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Dynamics of the climax and attack communities in cystic fibrosis

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Lung infections are one of the most severe health concerns and the leading cause of death for individuals with cystic fibrosis (CF). Bacteria colonize the viscous mucus characteristic of CF lungs and are predicted to influence, and be influenced by, varying oxygen concentrations within mucus-plugged CF airways. Moreover, the role of anaerobic bacteria in CF lungs remains unclear. In this study, we developed novel mathematical models of two bacterial communities, the aerobic climax community and anaerobic attack community, in the lungs of CF patients and evaluated the role of oxygen availability to alter the composition of the bacterial communities. Two approaches were implemented: an ordinary differential equation-based model to gain basic insights into the community dynamics, and agent-based models to explore the impact of spatial heterogeneity. These models were consistent with the data from a patient undergoing interrupted treatment for a CF caused lung infection. Models were analyzed to determine conditions that minimized the pathogenic attack community with attack-specific antibiotics and increased oxygen concentration. The models were also used to investigate how spatially dependent oxygen affects community dynamics. Overall, the results suggested that oxygen availability and targeted antibiotic use can play a critical role in maintaining a low level of attack community associated with CF patients' severe health conditions.