Biofilms are ubiquitous in medical, environmental, and engineered microbial systems. The majority of naturally occurring microbes grow as mixed species biofilms. These complicated consortia are comprised of a large number of cell populations with complex interactions and can be viewed as three-dimensional structures. While foundational to the vast majority of microbial life on the planet, the basic design principles including resource allocation strategies of consortia biofilms have not been studied systematically.

Recent research has demonstrated that biofilms are dynamic systems that can change over time. Understanding the mechanisms that drive these changes is crucial for devising rational biofilm control strategies. This is particularly true for chronic wounds, which are characterized by the presence of biofilms. Despite their large impact on societal health, there are no systems-based computational models of microbial consortia responsible for biofilm formation in chronic wounds. We believe our model will enable the predictive testing of emerging consortia properties including enhanced nutrient accessibility, nutrient utilization, and antibiotic tolerance and will provide the necessary knowledge for devising rational biofilm control strategies.

The multi-scale chronic wound biofilm simulator enables an investigation of system properties that induce the observed behavior and the associated control of biofilm properties. Interactions among species are captured in a multi-scale manner using spatial and temporal scales. Predictions for two species biofilms of thickness 12 um with different species interaction mechanisms. Base case (BC) competition for the nutrients glucose and oxygen. Cross-feed (CF) nutrient competition plus cross-feeding of lactate, succinate and acetate. Lysis (L): nutrient competition plus P. aeruginosa mediated lysis of S. aureus. Aerolysin (A): nutrient competition plus P. aeruginosa mediate lysis of S. aureus. Predicted resource concentration gradients and resource acquisition rates.

Despite their large impact on societal health, there are no systems-based computational models of microbial consortia responsible for biofilm formation in chronic wounds. The authors would like to acknowledge Poonam Phalak, Matthew W. Fields, and Michael A. Henson for their contributions to this work.

References

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1. ABSTRACT

2. Chronic Wounds & Biofilms

3. Experimental Chronic Wounds Model System

4. In Silico Multiscale Dynamic-Spatial Consortia Model

5. Consortia, Cell Interactions and Enhanced Resource Usage