Transient Dynamics of Infection Transmission in an Intensive Care Unit

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Healthcare-associated infections (HAIs) represent a threat to healthcare quality. These pathogens are characterized by sporadic outbreaks and introduction from the community. Thus, the transient dynamics of HAI models are of special interest. We consider three models of an ICU, varying its population structure, from a mass-action model to a meta-population model. R_0 is calculated for the systems using the Next Generation Matrix method. In the meta-population model where patients are assigned to specific nurses, we use time-to-event analysis to examine whether the initial position of colonized patients impacted the time until pathogen acquisition events. Absent the admission of colonized patients, a mass-action model with homogeneous staff has the highest R_0 at 0.34, while the other models have lower identical R_0s ($R_0 = 0.28$). For the meta-population models, we show that starting conditions where two colonized patients are cared for by different nurses result in faster acquisition of the pathogen by additional patients, but this difference fades by the third or fourth acquisition event. Simulations where the patients were cared for by different nurses were less subject to stochastic extinction. These results demonstrate the importance of recognizing heterogeneity in healthcare worker behaviors, contact patterns, and the utility of grouping patients with similar conditions ("cohorting") in preventing disease transmission. Further, in circumstances where initial dynamics of an infection are of interest these results highlight the importance of subtle initial conditions on model outcomes for infections with low rates of community importation.