Statistical Models of Infectious Disease
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Terms: Fall/Winter
Prerequisites: Math 245 and 275. Math 241 is helpful but not at all required.

Infectious disease epidemics are a perfect storm of uncertainty. The current SARS-CoV-2 epidemic provides a case study: an unknown number of people are infected, and every day another unknown number of develop a new, potentially asymptomatic infection; the duration of infectiousness is unclear; the mode of transmission and degree of contagiousness are not fully understood; and even after five months, estimates of the case fatality rate still vary by an order of magnitude. And that's not to mention mutation of the virus, or the effect of seasonal temperature changes, or heterogeneity of individual risk factors...

But accurate predictions are essential to controlling the threat of an epidemic. In light of all this uncertainty, how can we use the information we have to predict the course of an epidemic, and identify appropriate interventions? Enter the heroes of this story: statisticians.

This comps will be an introduction to the statistical methods used to model infectious disease. These techniques allow us to estimate important epidemiological parameters (e.g. the reproduction number, mean duration of infectiousness), forecast the trajectory of an epidemic, and predict the consequences of intervention strategies.

We'll start with a brief introduction to infectious disease epidemiology and an overview of different modeling approaches, including network models of transmission, compartment-based ODE models and their stochastic relatives, and generalized linear mixed models. We'll investigate the advantages and disadvantages of these modeling strategies in a variety of disease settings, and explore their implications for epidemic control. Time and student interest permitting, we will also explore the related question of 'now-casting': estimating the true current number of cases of a disease, based on the existing history of reported cases.

Data applications can be determined by group interests; there exists a great deal of publicly-available data from the current SARS-CoV-2 epidemic, but the methods we'll discuss have broad utility. In any case, we'll use R extensively to analyze real-world disease data, and to simulate and compare intervention strategies.