THE EFFECT OF MITIGATION MEASURES IN THE SPREAD OF COVID-19

Throughout the spring semester, students and faculty tackled real world challenges in the midst of the COVID-19 crisis, examining the spread of the virus and effects of social distancing, PPE, handwashing, and surface decontamination.

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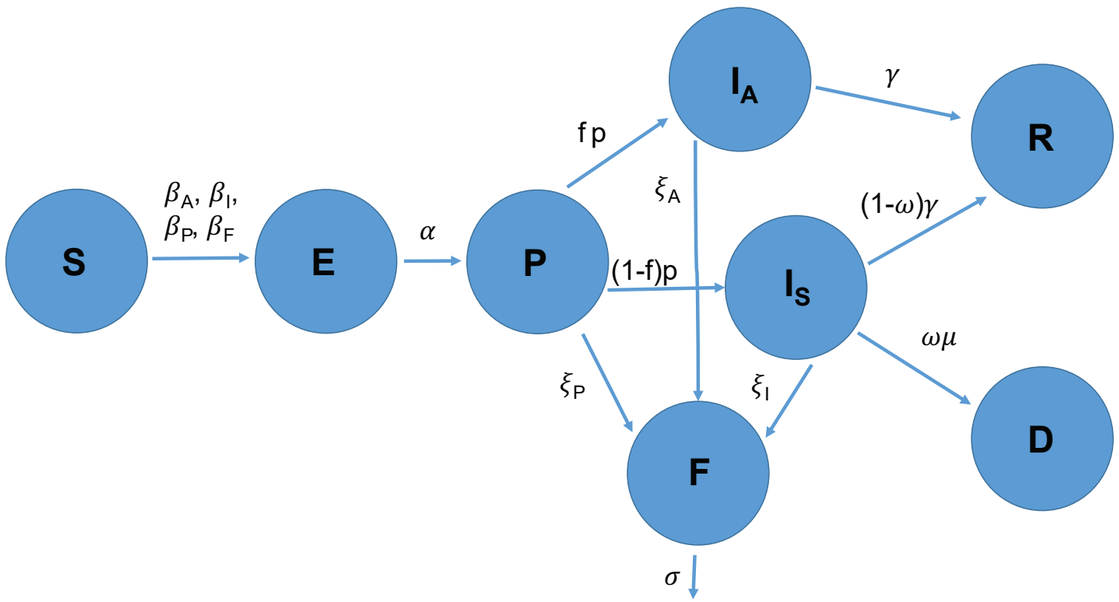
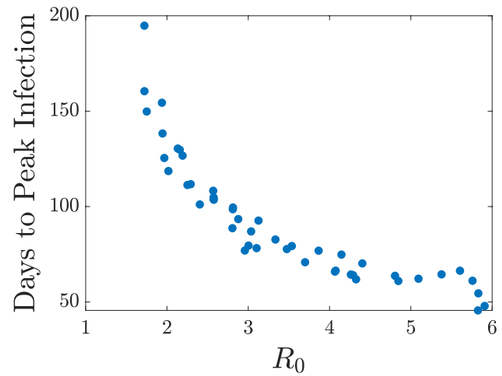
We investigate the role of precautionary measures, such as social distancing, personal protective equipment, frequent handwashing, and surface decontamination in the spread of COVID-19. COVID-19 is the disease caused by the novel coronavirus SARS-CoV-2 and, among others, is transmitted directly from human to human. Since it was found that the virus remains viable on various surfaces for a substantial time, we also include fomite transmission in our model. Examples of fomites (F) are doorknobs, elevator buttons, toys at a daycare center, and handrails in the hallways of nursing homes. We divide the population into compartments depending on infection status: susceptible (S), exposed but not infectious (E), three classes of infectious hosts (pre-symptomatic (P), asymptomatic (I_A), and symptomatic (I_S)), recovered (R), and deceased (D). The model is shown schematically in the figure below.

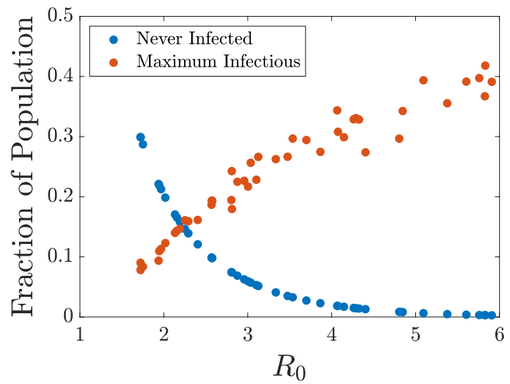


For this model, we have found the basic reproductive number R_0, namely the number of secondary infections generated by an infectious host, when placed in a totally susceptible population. This number depends on most of the parameters in the system in the following way:

$$R_0 = \frac{\beta_P}{p} + f\frac{\beta_A}{\gamma} + (1-f)\frac{\beta_I}{(1-\omega)\gamma+\omega\mu} + \frac{\beta_F}{\sigma}\left[\frac{\xi_P}{p} + f\frac{\xi_A}{\gamma} + (1-f)\frac{\xi_I}{(1-\omega)\gamma+\omega\mu}\right].$$

We also found the time it takes to get to peak infection ($P+I_A+I_S$), the number of infected hosts at that time, and the number of hosts remaining in compartment S after the first wave of the outbreak has ended. There is a lot of variation and uncertainty in the parameter ranges, so the dots in the following figures represent different epidemiologically feasible scenarios.





Taking precautionary measures can effectively reduce the basic reproduction number, as well as result in significantly fewer people ever becoming sick. In the following figures, we assume that precautionary measures are implemented once about 0.3% of hosts are infectious. The effective reductions of the β and ξ parameters are about 60% for the asymptomatic and 75% for the symptomatic compartments.