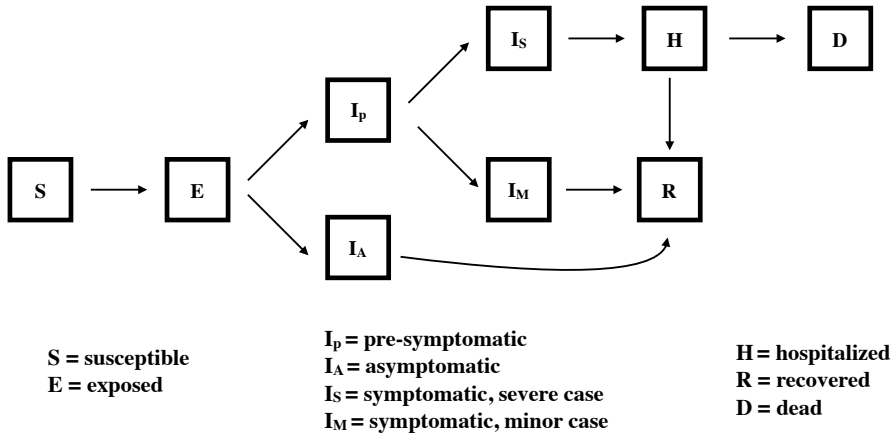
Overview

We develop a compartmental model of COVID-19 to evaluate control efforts through non-pharmaceutical interventions. Currently, with this model we are aiming to illustrate possible trajectories under different hypothetical scenarios rather than trying to match exact dynamics of a location. We have turned the model into an interactive app to allow viewers to choose interventions over different time periods to consider the impact of the onset and duration of those interventions as well as the potential for resurgence after control measures are lifted (https://jritchie.shinyapps.io/covid_interventions/).

Model Structure

Our model explicitly tracks nine compartments, including exposed, asymptomatic, presymptomatic, symptomatic, hospitalized, and recovered (Figure 1). We assume that all individuals who are exposed go through an incubation period. A portion of those who then become infectious remain asymptomatic for the entire infection (I_a) while individuals who go on to become symptomatic first go through a pre-symptomatic but infectious state (I_p). Those who show symptoms are further divided between those with mild symptoms (I_m) and severe symptoms (I_s) who require hospitalization. We assume that after admission to the hospital, no onward transmission occurs. The model is implemented in R with the package "pomp" using a stochastic simulator where the movements between compartments are multinomially distributed based on transition rates.

Figure 1: Model schematic



Implementation of Interventions

Crucially, our modeling framework allows for different types, intensities, and durations of interventions to be implemented, and thereby illustrates how these interventions impact dynamics and resultant number of COVID-19 cases and fatalities through time. We currently consider 3 possible interventions that are can be implemented at different times during the simulation:

1. social distancing for a set duration (applied as a scaling of the transmission rate for all infected individuals)
2. social distancing triggered by the number of hospitalized individuals crossing a threshold (applied as above)
3. isolation of symptomatic individuals (applied as a scaling of the transmission rate for only symptomatic individuals I_s and I_m)

In the future, we are considering additional interventions and scenarios including contact tracing with efficacy dependent on the testing capacity, fatality and hospitalization rates dependent on the age structure of a population, and fatality rates further dependent on hospital capacities.