1. SIRF/SHERIF model

We have seen a discrete-time version of the SIR (susceptible/infected/recovered) model in class; the continuous-time variant is even better known. There are hundreds of variants of the SIR model dealing with various complexities of disease biology and human society (Hethcote 1994). One recent variation is the SHERIF model (Champredon et al. 2018), developed to analyze the recent West African Ebola outbreak, which adds Hospitalized, Exposed, and Funeral compartments to the SIR model (the order is chosen for pronounceability). To make things simpler, consider the SIFR model, which includes transmission caused by contact occurring at funerals.

$$\frac{dS}{dt} = -\beta SI - \beta_F SF$$
$$\frac{dI}{dt} = \beta SI + \beta_F SF - \gamma I$$
$$\frac{dF}{dt} = \gamma I - \alpha F$$
$$\frac{dR}{dt} = \alpha F$$

Since this model at the moment has no births, the only possible equilibrium is where everyone is recovered. Add in vital dynamics such as deaths due to mortality (-uS, -uI, -uF, -uR) and births to the S class (+uN), where N=S+I+F+R, this way the population is kept constant. If necessary drop the F compartment entirely.

Complexities (things to try to make the model harder):
Add the EH compartments back in.
Make a stochastic version
Allow for a transfer from I directly to R (bypassing F).