Discussion 3: changing parameters

Today we will be will use an implementation of the SIR model similar to week 2 to do parameter exploration. Remember, to solve ODE models we use an ODE solver, in this case function *lsoda* from R package *deSolve*.

The SIR model with births and deaths

In the model below, the population is at equilibrium except for disease-induced mortality, ie natural deaths = natural births.

$$\frac{dS}{dt} = m(S + I + R) - mS - bSI$$

$$\frac{dI}{dt} = bSI - (m + v)I - \gamma I$$

$$\frac{dR}{dt} = \gamma I - mR$$

1. Go over each equation and identify all of the state variables and parameters.

2. In a new R script, use function lsoda from package deSolve to simulate and plot the model above. You can use the incomplete code below or write your own from scratch.

   Remember function lsoda takes 4 parameters: y, times, func, and parms. Set up all of the starting values and parameters you will need, as well as the time points you will want to calculate values for.

```
###### Set up ##########
require(deSolve)
I0 = .0001
S0 = 1-I0
R0 = 0
state_vars = c(SS = S0, II = I0, RR = R0)

#Generate a  series of times at which you want the ODE solver
#to output population sizes
tseq <- seq(0, 60, by = .1)

#Generate a vector of parameter values.
pars <- c(beta = 1.4, gamma = 0.14, m = 0.0000391, v = 0.00001)




# function will be your *func* argument to lsoda.
#It needs to get a time point, the
#state variables, and the
#parameters as arguments
#it returns a list whose first element
#is a vector with the derivative values.
```

```r
SIR_system <- function(tseq, state_vars, pars){
    SS = state_vars[1]
    II =
    RR =

    beta = pars[1]
    gamma =
    m =
    v =

    dS_dt =
    dI_dt =
    dR_dt =

    return(list(c(dS = dS_dt, dI = dI_dt, dR = dR_dt)))
}


output <-

plot(output[,1], output[,2], type = "l", lwd=2, xlab="time", ylab="N")
lines(output[,1], output[,3], col=2, lwd=2)
lines(output[,1], output[,4], col=3, lwd=2)
```

3. For the model above what is:
    a) the time and value of I at the peak of the outbreak
    b) the time point where the epidemic ends
4. Alter your code to implement each of the following interventions, and then **recalculate the answers to exercise 5**.

a) A vaccination campaign that takes half of the current susceptible population and makes it recovered. This happens as soon as 10% of the population is infected.

b) A control campaign that reduces transmission by 20% when the susceptible population is down to 80%.

c) A quarantine that removes half of the infected population right when the outbreak peaks.

d) A new treatment that makes recovery 10% faster.

5. Without running the model, what do you think happens if you make the birth rate very high? Why? Run the model to confirm if you are correct.