Ebola Models in Liberia

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Background Information and Setup

History and Context of Ebola and Liberia

- Ebola isn't contagious until it's symptomatic
- It's spread through contact with an infected's body fluids and the immunoprivileged body fluids of the recovered
- Ebola provides immunological resistance for 8-10 years after recovery

- Liberia is an African nation in the western part of the continent
- It has suffered from Ebola before, most notably the 2014-2016 outbreak
- Harper is about the 4th largest city in Liberia
- Monrovia is the largest, and the capitol

Assumptions

1. Ebola is not infectious before it's symptomatic
2. Assume no dormancy period
3. Assume no births, deaths, migrations
4. Assume the dead are mopped up in a day
5. Time is measured in days
6. Infection rates don't change seasonally
7. Recovered people don't infect others
8. There are no floors or ceilings in this model
9. Assume people listen to the quarantine
10. Assume incubation period is 9 days
11. Assume infectious period is 25 days
12. Assume r0 is 1.75
13. Assume mortality rate of 50%
14. Assume populations are 32661 (Harper), 1021762 (Monrovia) per 2020 UN estimates

Mathematical Models

Variables

- T = time (in days)
- Beta = infection rate of the symptomatic = .0000214
- Delta = rate people become symptomatic = 1/9
- Mu = proportion of infected who die = .02
- Lambda = proportion of infected who recover and become immune = .021
- Xi = rate of quarantining = 1/14

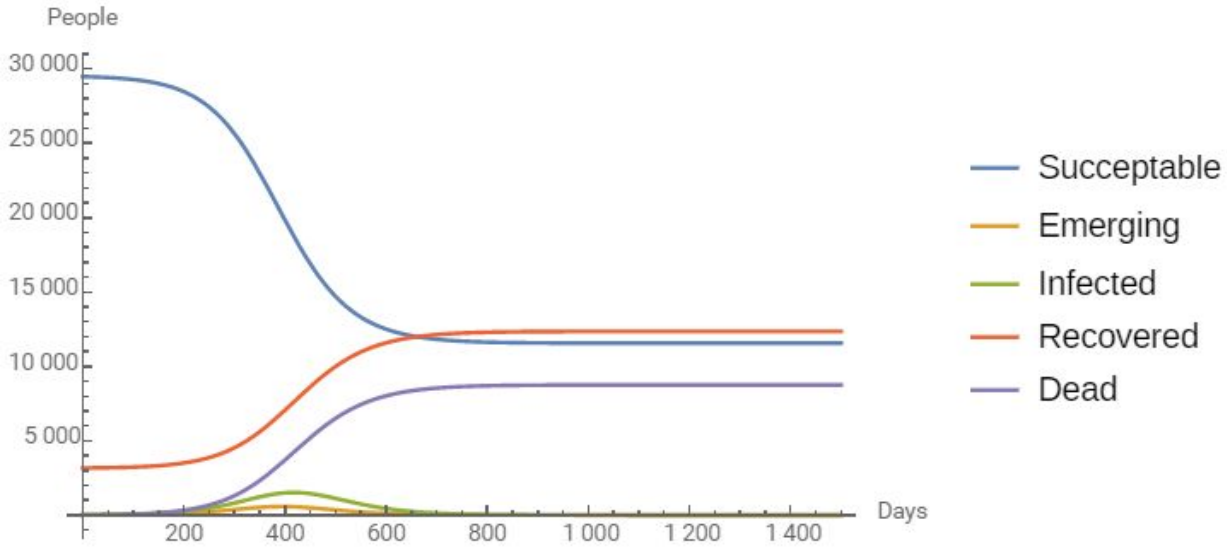
Initial Conditions

Model for Harper, Liberia

- S0 = 29478
- E0 = 0
- I0 = 1
- R0 = 3163
- D0 = 0
- Q0 = 0

Model for Monrovia, Liberia

- S0 = 1018589
- E0 = 0
- I0 = 1
- R0 = 3163
- D0 = 0



Equations:

$S(t) = -\beta S(t) I(t)$

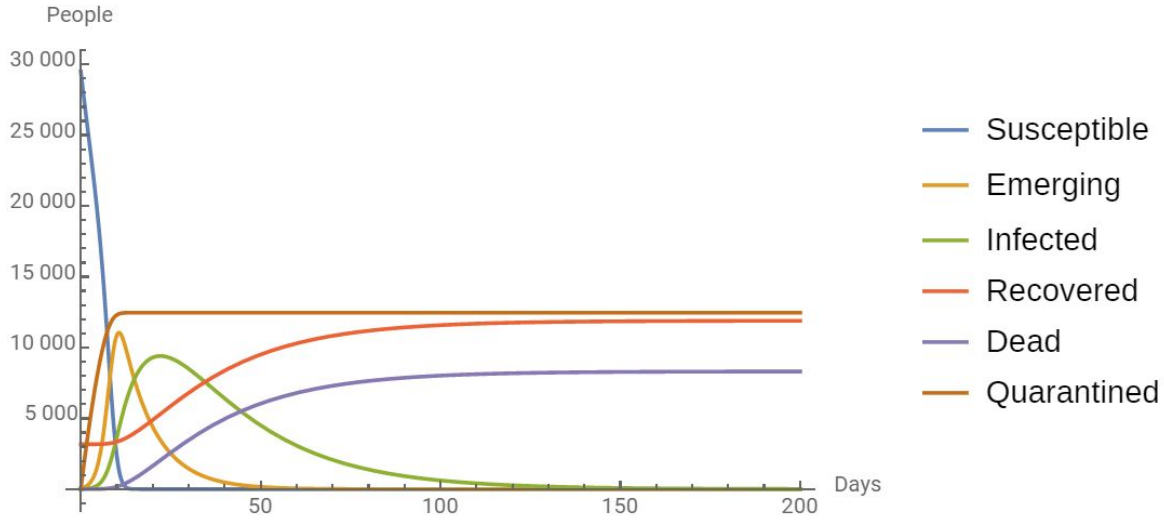
$E(t) = \beta S(t) I(t) - \delta E(t)$

$I(t) = \delta E(t) - \lambda I(t) - \mu I(t)$

$R(t) = \lambda I(t)$

$d(t) = \mu I(t)$

Given I0 = 20, Find when S(x) = 0 for Harper, Liberia, were a breakout happen in 2020.



Equations:

S(t) = -beta*S(t)*I(t) - xi*S(t)

E(t) = beta*S(t)*I(t) - delta*E(t)

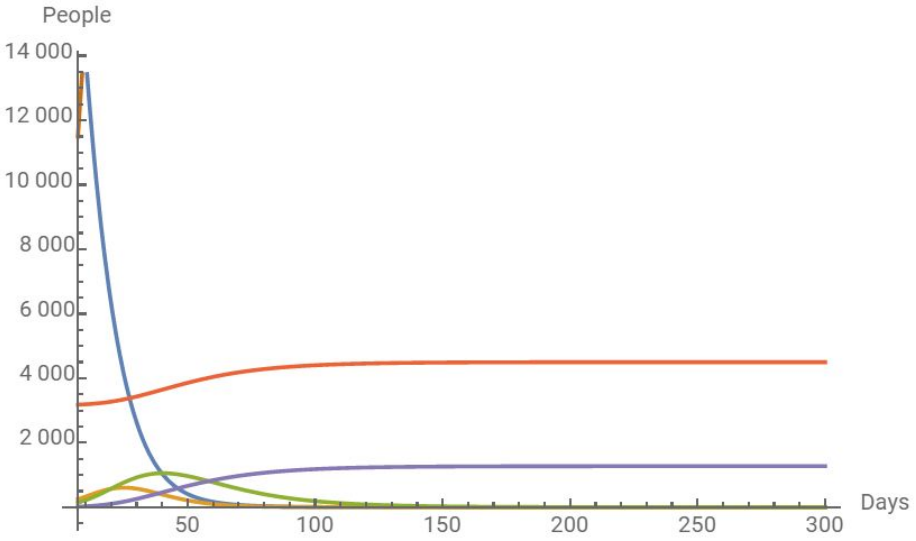
I(t) = delta*E(t) - lambda*I(t) - mu*I(t)

R(t) = lambda*I(t)

D(t) = mu*I(t)

Q(t) = xi*s(t)

Find Model 1, but with a 50% weekly quarantine



Note: All initial conditions for this model are replaced with Harper Non Quarantine model at Day 7.

Equations:

$S(t) = -beta*S(t)*I(t) - xi*S(t)$

$E(t) = beta*S(t)*I(t) - delta*E(t)$

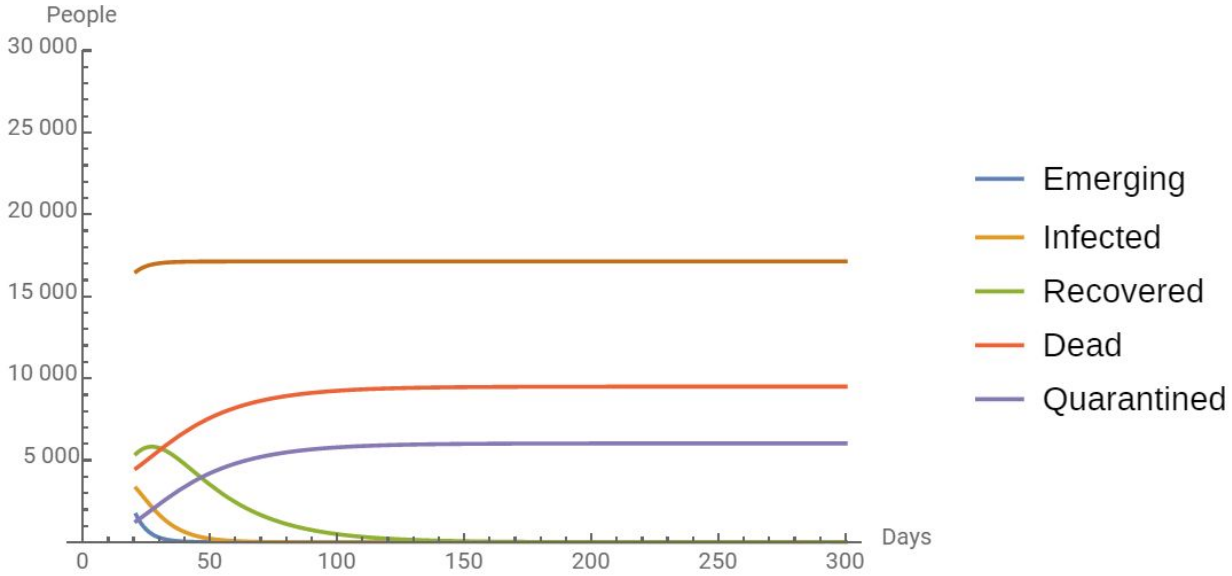
$I(t) = delta*E(t) - lambda*I(t) - mu*I(t)$

$R(t) = lambda*I(t)$

$D(t) = mu*I(t)$

$Q(t) = xi*s(t)$

Find Model 1 with Quarantine, but with a 1 week delay



Note: All initial conditions for this model are replaced with Harper Non Quarantine model at Day 21.

Equations:

$S(t) = -beta*S(t)*I(t) - xi*S(t)$

$E(t) = beta*S(t)*I(t) - delta*E(t)$

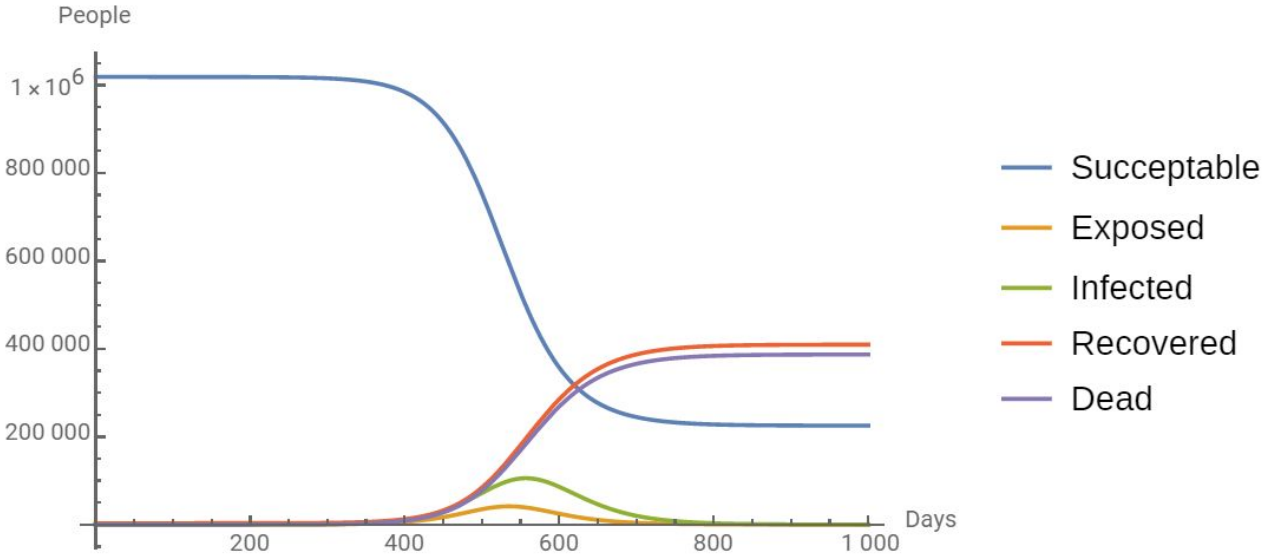
$I(t) = delta*E(t) - lambda*I(t) - mu*I(t)$

$R(t) = lambda*I(t)$

$D(t) = mu*I(t)$

$Q(t) = xi*s(t)$

Find Model 1 with a Quarantine, but with a 3 week delay



Equations:

$S(t) = -\beta S(t) I(t)$

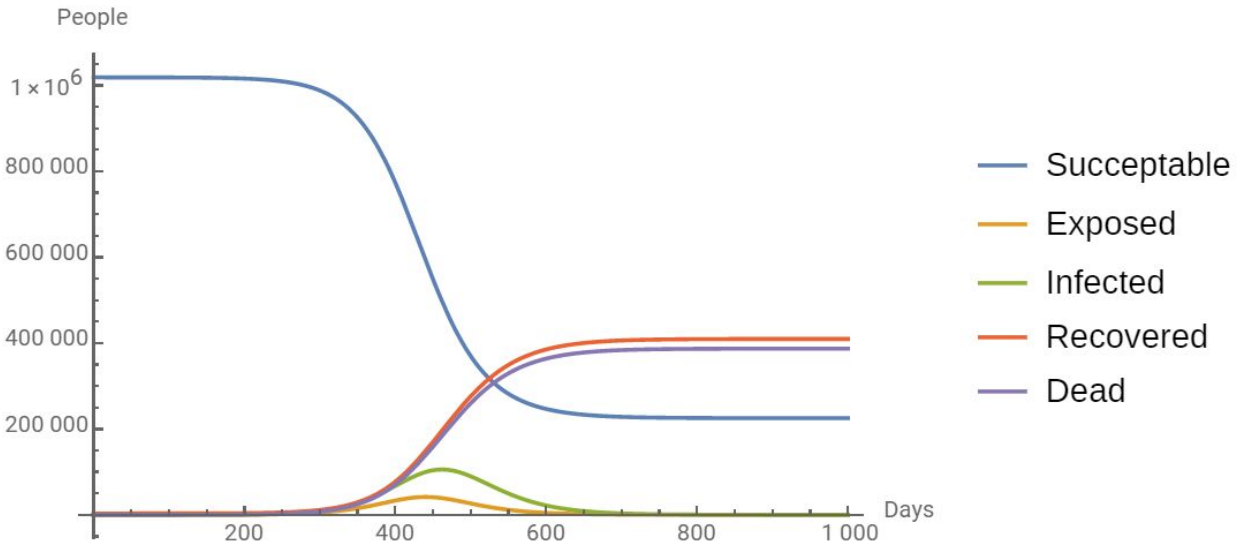
$E(t) = \beta S(t) I(t) - \delta E(t)$

$I(t) = \delta E(t) - \lambda I(t) - \mu I(t)$

$R(t) = \lambda I(t)$

$d(t) = \mu I(t)$

Find the model of the Ebola outbreak in Liberia's capital, Monrovia, without intervention.



Equations:

S(t) = -beta*S(t)*I(t)

E(t) = beta*S(t)*I(t) - delta*E(t)

I(t) = delta*E(t) - lambda*I(t) - mu*I(t)

R(t) = lambda*I(t)

d(t) = mu*I(t)

Find Model 4 but let I0 = 5

Resources

Doucleff, Michaeleen. “No, Seriously, How Contagious Is Ebola?” *NPR*, NPR, 2 Oct. 2014, www.npr.org/sections/health-shots/2014/10/02/352983774/no-seriously-how-contagious-is-ebola.

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