Approaching Addiction Using an SIR Model

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Motivation

◦ We are aiming to model addiction as an infectious disease, namely alcoholism

◦ The goal is to see what factors are responsible for moving people from susceptible to infected to recovered populations.

Milestone 1

- Read Koss survey to understand what an SIR model is
- Saw 7 different applications of the model
- Modeling addiction seemed to be the most interesting

Assumptions

- S+I+R=N; I and A may be used interchangeably: I for "infected" and A for "alcoholic"
- Susceptible individuals do not consume alcohol or do not consume alcohol to the point of alcoholism
- Leave susceptible group by going to the infected group.
- A recovered individual is receiving professional treatment

Milestone 2

- Validation: reproduced results from the graphs in Walters article
- Difficulty arose in finding the correct initial values
- After correcting initial values, our reproduction was correct.

$$\dot{S} = \mu N - \frac{\beta A S}{N} + \gamma R - \mu S,$$
$$\dot{A} = \frac{\beta A S}{N} + \rho R - (\varphi + \mu) A,$$
$$\dot{R} = \varphi A - (\rho + \mu + \gamma) R,$$

S(t) = susceptible population
I(t) = infected population
R(t) = recovered population

β = rate at which sufficient contacts occur

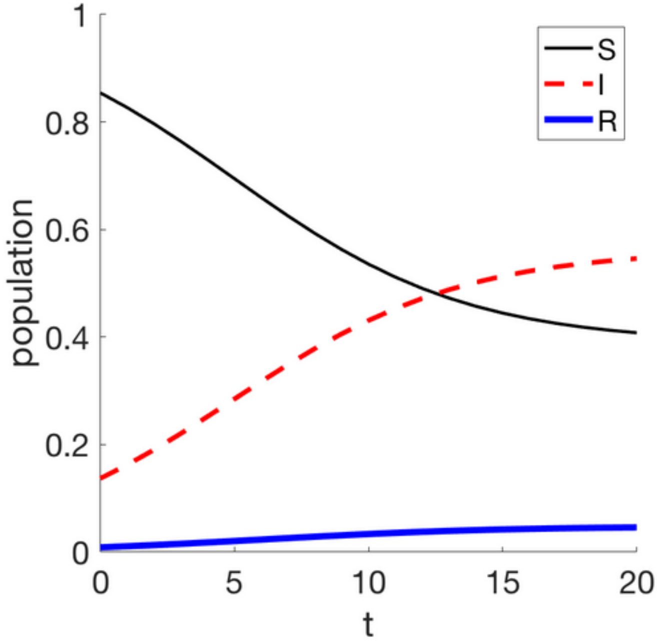
φ = rate at which individuals may move to the recovery class by entering treatment

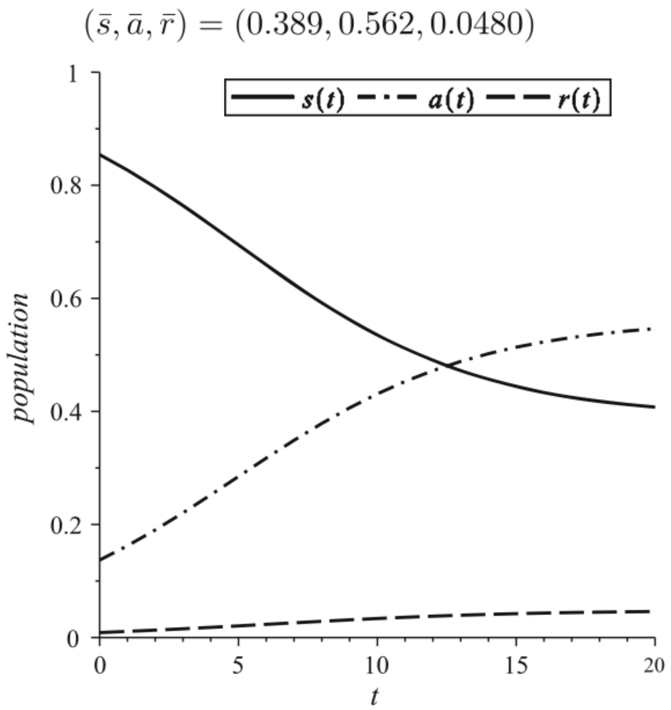
μ = the rate at which individuals enter and leave the population

ρ = rate at which individuals relapse back to I(t)

λ = rate at which individuals recover and thus return to S(t)

N = total population

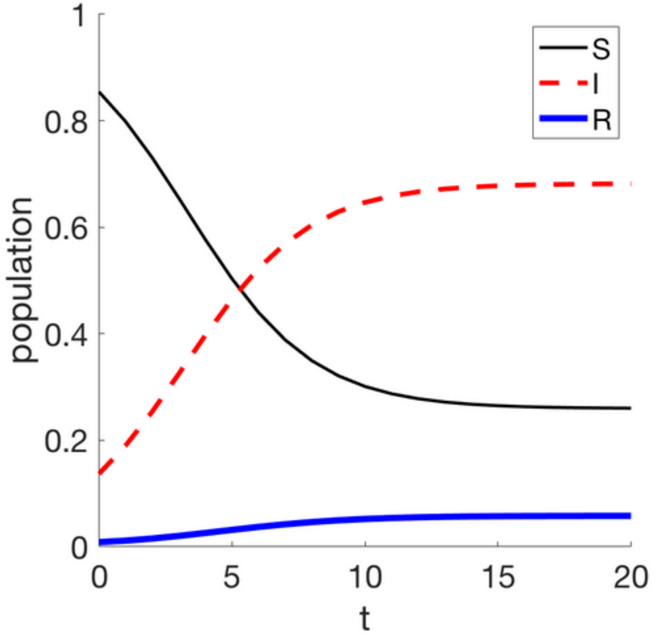


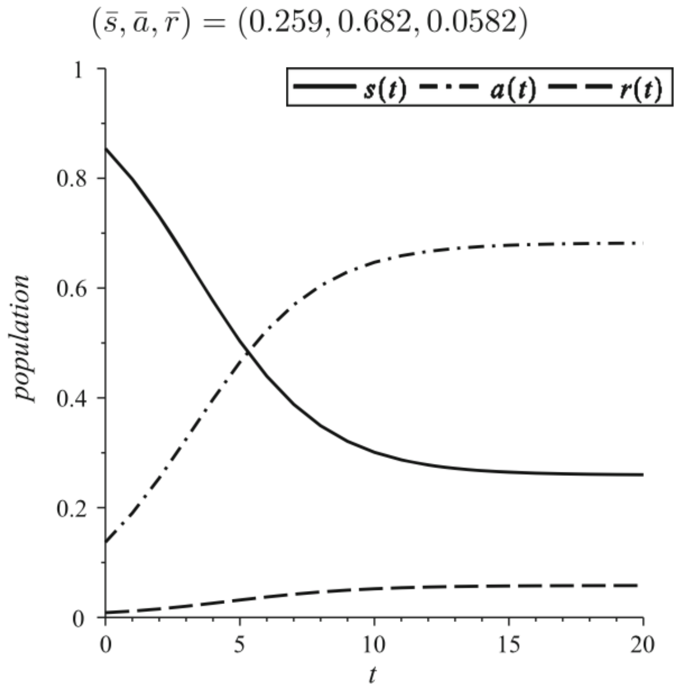


$\beta = 0.4$ $\mu = 0.143$ $S(0) = 0.8543$

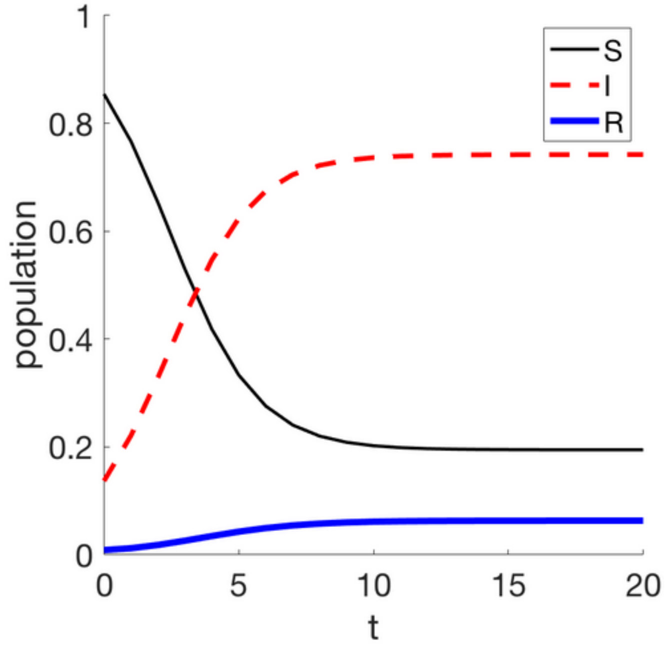
$\lambda = 0.00659$ $\rho = .576$ $I(0) = 0.137$

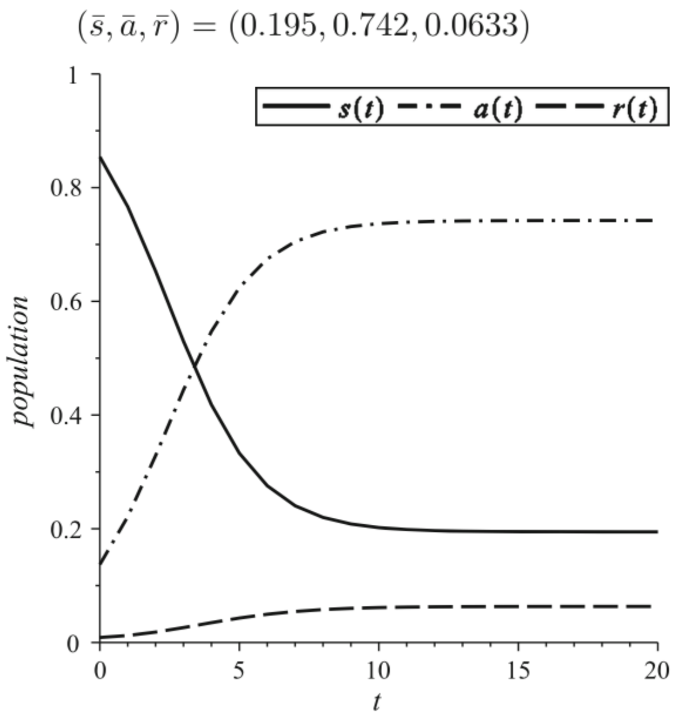
$N = 1$ $\varphi = .0619$ $R(0) = 0.00874$





$\beta = 0.6$	$\mu = 0.143$	$S(0) = 0.8543$
$\lambda = .00659$	$\rho = .576$	$I(0) = 0.137$
$N = 1$	$\varphi = .0619$	$R(0) = .00874$



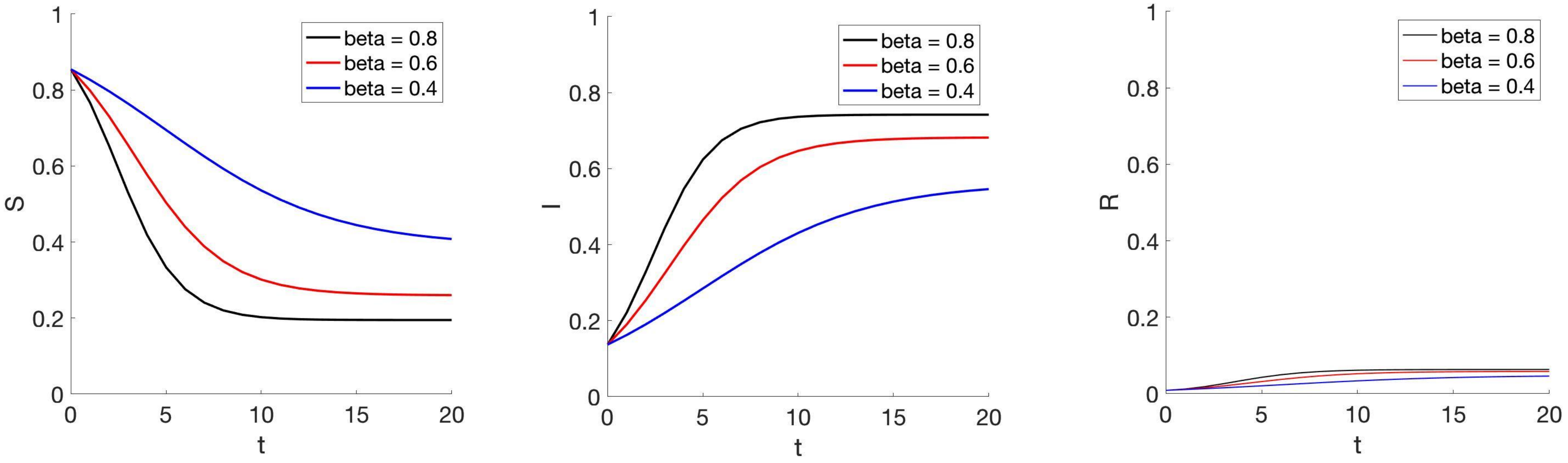


$\beta = 0.8$	$\mu = 0.143$	$S(0) = 0.8543$
$\lambda = .00659$	$\rho = .576$	$I(0) = 0.137$
$N = 1$	$\varphi = .0619$	$R(0) = .00874$

Milestone 3

- Performed sensitivity analysis by slightly changing β which represents the rate at which sufficient contacts occur.
- Since S and I are inverses of each other, as β increases the rate at which individuals both become infected and leave the susceptible population increases.

Sensitivity Analysis



Relation to MATH 3316

- System of first order differential equations
- We’ve learned how to solve systems of differential equations in this class
- Each equation is the derivative of a function that represents the growth rate of the individual populations (S, I, R).
- These equations are similar to the initial value problems that we’ve solved in class

Works Cited

Koss, L. (2019). SIR Models: Differential Equations that Support the Common Good. CODEE Journal, 12(1), 61–71. doi:10.5642/codee.201912.01.06

Walters, C. E., Straughan, B., & Kendal, J. R. (2012). Modelling alcohol problems: total recovery. Ricerche Di Matematica, 62(1), 33–53. doi:10.1007/s11587-012-0138-0