SEIR Model Ext.

⇒ Assmp: Recovered people are immune to disease, exposed pop. can't spread disease, no birth or death rates, people are not dying due to disease

* Basic eq:

$$\frac{ds}{dt} = -\beta is$$

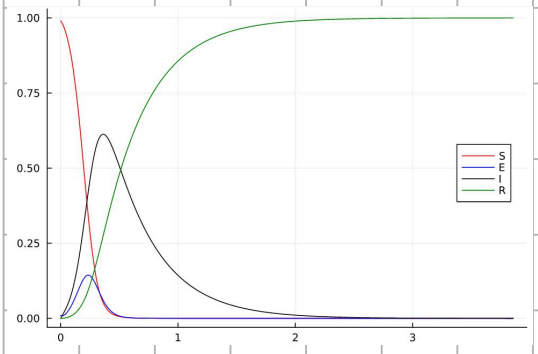
$$\frac{de}{dt} = \beta is - \sigma e$$

$$\frac{di}{dt} = \sigma e - \gamma i$$

$$\frac{dr}{dt} = \gamma i$$

$\beta = 1$
$\sigma = 1$
$\gamma = 0.1$

$s_0 = 0.99$
$e_0 = 0.01$
$i_0, r_0 = 0$



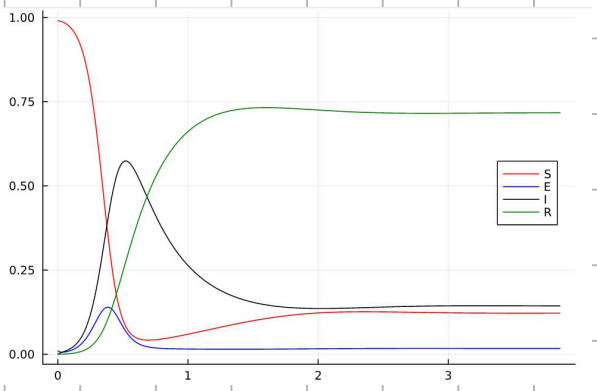
Since no one is dying due to disease & no birth & death rates are included, $s, e, i \to 0$ & $r \to 1$

* Changing β just changes the graph to shrink or stretch
* changing σ only changes the peak value of E graph & oppositely affects peak of infected.
* $\gamma \to$ as expected if more recovery happens fast

1. Adding birth & death rates: μ

→ if b.r & d.r are same

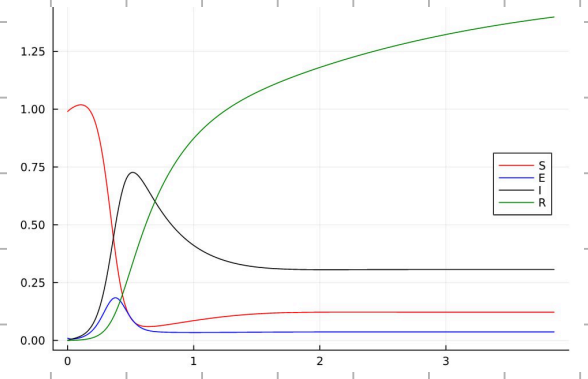
$$\dot{S} = -\beta i s + \mu - \mu S \qquad \mu = 0.02$$
$$\dot{e} = +\beta i s - \sigma e - \mu e$$
$$\dot{i} = \sigma e - \gamma i - \mu i$$
$$\dot{r} = \gamma i - \mu r$$



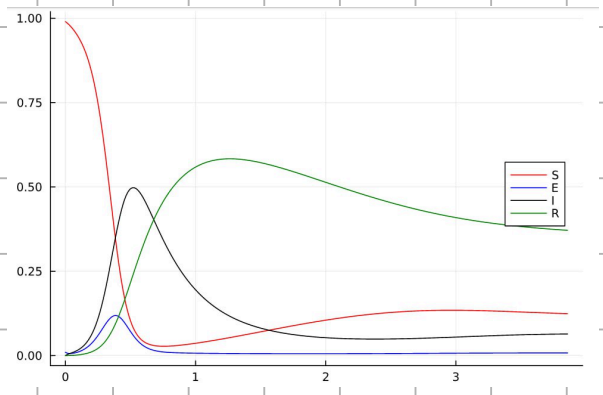
⇒ The disease doesn't stop (there is i at equilibrium)

$\left(R_0 = \frac{\beta}{\mu+\gamma} > 1 \text{ here so}\right)$

→ If I change br : $b.r > d.r$, then $\frac{dN}{dt} > 0$ & the recovery rate seems to grow over 1, remaining at some equilibrium : and then reaches.



$b.r > d.r$



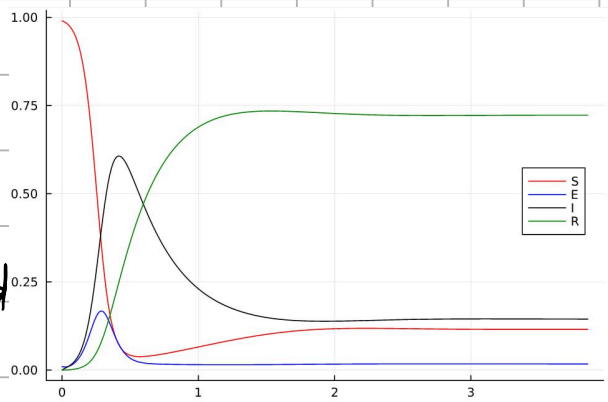
$d.r > b.r$

(recovered pop. goes down & reach an equilibrium)

Also $S_{eq} > i_{eq}$ in this case

2) Adding the fact that exposed pop. can also cause disease but at a lower rate comp. to infected & ($\mu = b.r = d.r$)

$$\dot{s} = -\beta i s + \mu - \mu s - \delta e s$$
$$\dot{e} = \beta i s + \delta e s - \mu e - \sigma e \qquad \delta = 0.5$$
$$\dot{i} = \sigma e - \gamma i - \mu i$$
$$\dot{r} = \gamma i - \mu r$$



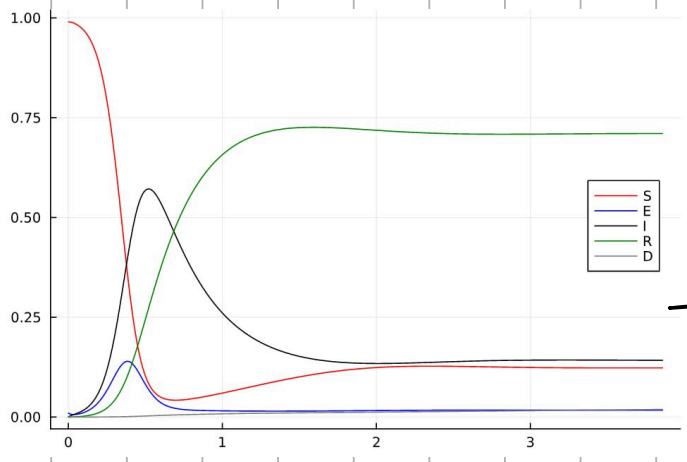
S_{eq} is slightly decreased
i_{eq} is slightly increased in this case

3) SEIRD model with $b.r = d.r$:
↳ Deceased from infected
so, they are put in some sep. compartment

$$\dot{s} = -\beta i s + \mu - \mu s$$
$$\dot{e} = \beta i s - \sigma e - \mu e$$
$$\dot{i} = \sigma e - \gamma i - \mu i - \kappa i$$
$$\dot{r} = \gamma i - \mu r$$
$$\dot{d} = \kappa i$$

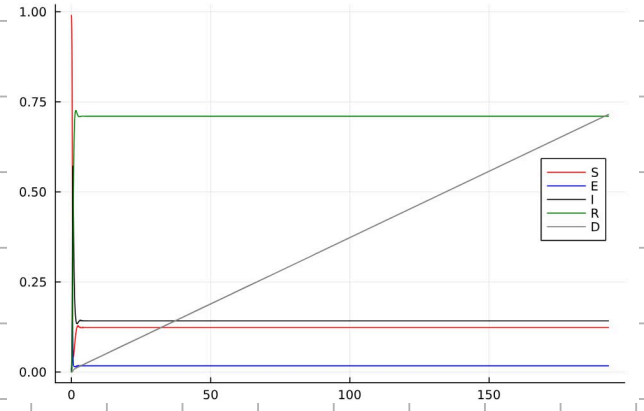
κ = death rate due to disease alone

for $\kappa = 0.01$ itself which is $<< \gamma = 0.1$ the graph of d increases linearly & so on



→ Initially D is very slowly increasing

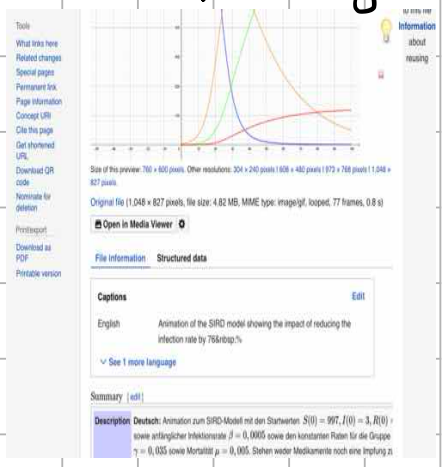
But... after times:



It crosses r & goes straight over 1 and so on.

But can adjust parameters like β to get a reasonable graph see this :

https://commons.wikimedia.org/wiki/File:SIRD_model_anim.gif



* Other models to think of but too much to write & execute

* SEIS model (recovered has no immunity so goes to sus. directly)

* SEIRS model (when recovered temporary immune or only few people are immune)

* SEIRV & SEIRVD models (V → vaccination)

* $SEIR_{SS}$ ⇒ SEIR model + Social Stress
↓

At beginning of epidemic people might be ignorant & careless, after time they get alarmed & epidemics may decline, and when this happens, still

overtime, people get tired of restrictions if new cases no. drops down, so it may increase & gain this can happen