

zombie

March 21, 2020

1 SIR model

```
[1]: import matplotlib
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from scipy.integrate import odeint

%matplotlib inline
```

1.1 Model

```
[2]: def system_fun(y, t, alpha, beta, gamma, zeta, mu, nu, tau):
    """system function
    """
    S, I, R, Q, D, AC = y

    derivatives = [
        -nu * S * I + alpha * R - beta * (I + AC) * S, # S
        beta * (I + AC) * S - (zeta + gamma * (S + AC + R) + mu) * I, # I
        zeta * (I + Q) + tau * AC - alpha * R, # R
        gamma * (S + AC + R) * I - (mu + zeta) * Q, # Q
        mu * (I + Q), # D
        nu * S * I - tau * AC, # AC
    ]

    return derivatives
```

```
[3]: PARAMS = {"alpha": 0, "beta": 1, "gamma": 0, "zeta": 0.2, "mu": 0.01, "nu": 0,
    ↪ "tau": 0}
INIT_VALUES = {"S": 0.99, "I": 0.01, "R": 0, "Q": 0, "D": 0, "AC": 0}

def solve(init_values=INIT_VALUES, model_params=PARAMS):
    """Return simulation result
    """
    y0 = [init_values[key] for key in ("S", "I", "R", "Q", "D", "AC")]
```

```

t = np.linspace(0, 100, 10000)
fun = lambda y, t: system_fun(y, t, **model_params)
soln = odeint(fun, y0, t)

return soln

```

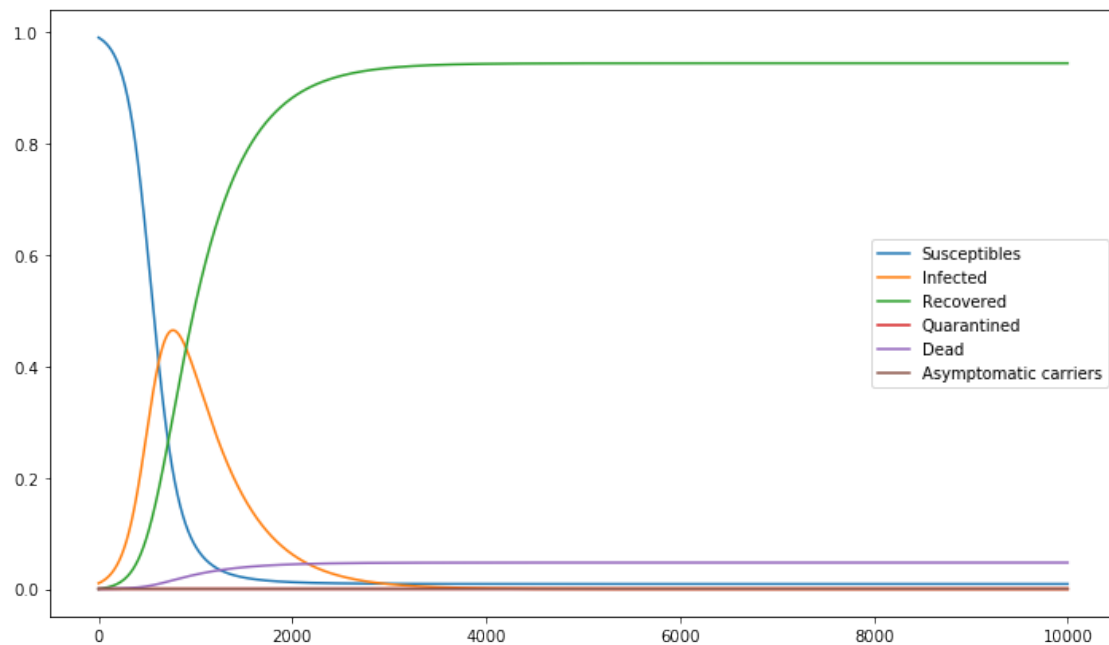
```

[4]: def zombie_plot(init_values=INIT_VALUES, model_params=PARAMS):
    """Plot simulation
    """
    soln = solve(init_values, model_params)
    df = pd.DataFrame(
        soln,
        columns=(
            "Susceptibles",
            "Infected",
            "Recovered",
            "Quarantined",
            "Dead",
            "Asymptomatic carriers",
        ),
    )
    df.plot(figsize=(12, 7))

```

1.2 SIR with low death rate

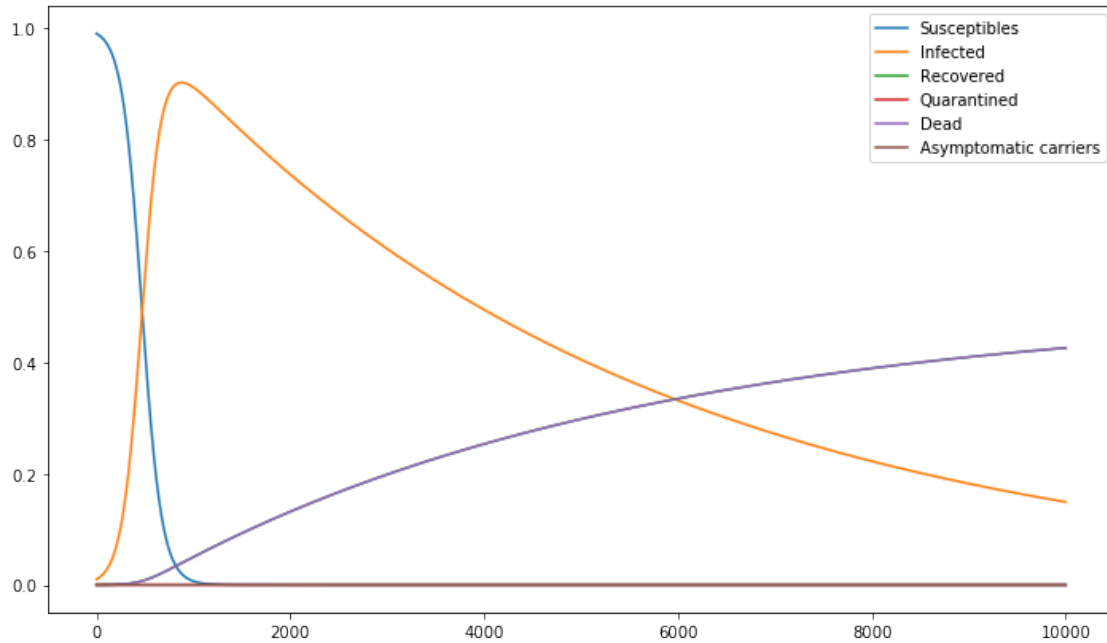
```
[5]: zombie_plot()
```



almost everyone is infected and recover

1.3 Low recovery rate

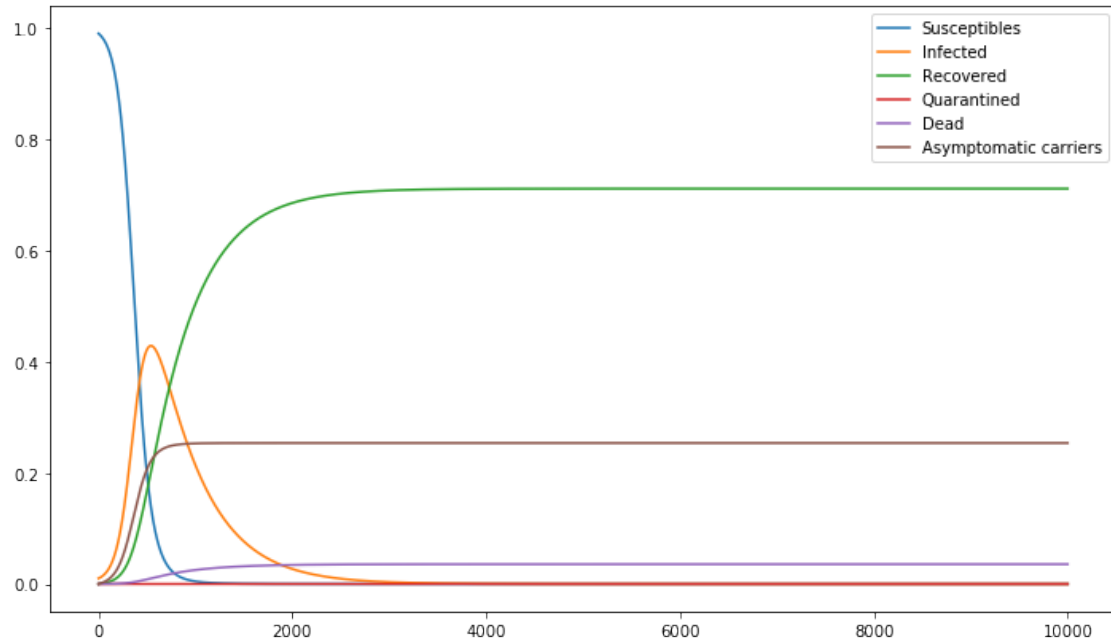
```
[6]: params = PARAMS.copy()
      params["zeta"] = 0.01
      zombie_plot(model_params=params)
```



More dead people than recovered.

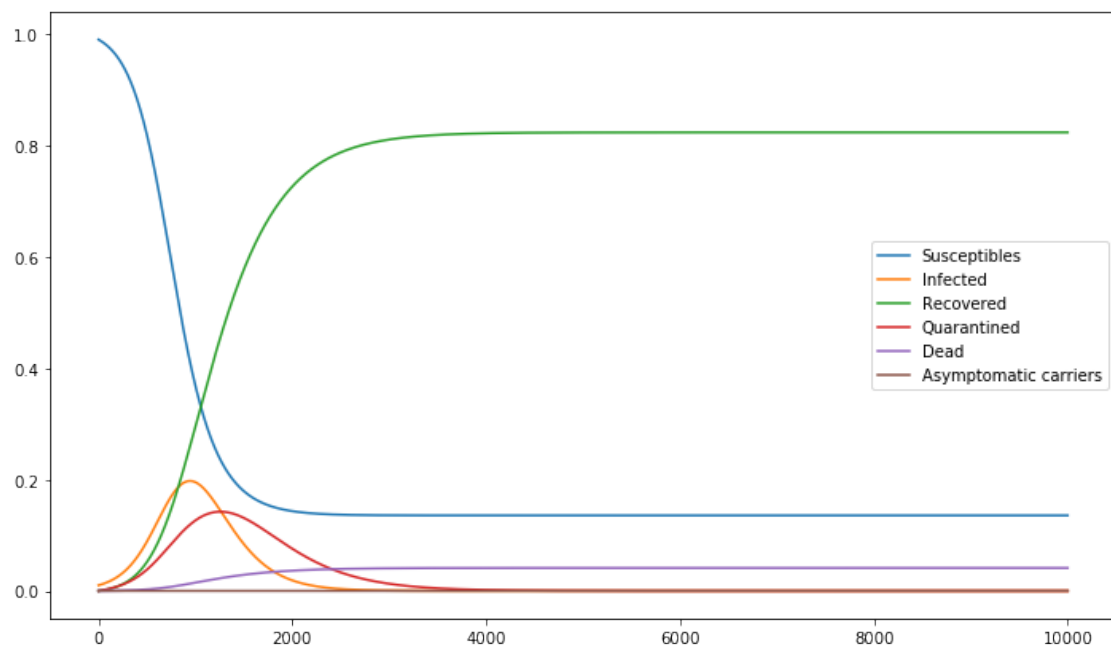
1.4 with asymptomatic carriers

```
[7]: params = PARAMS.copy()
      params.update({"nu": 0.5})
      zombie_plot(model_params=params)
```



1.5 with quarantine

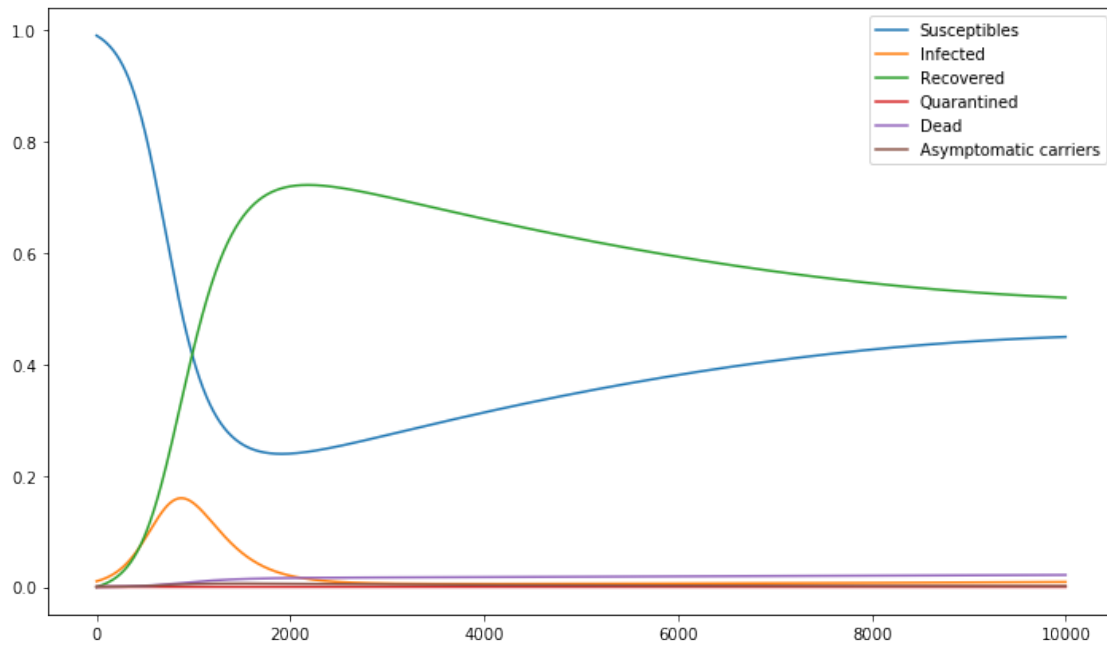
```
[8]: params = PARAMS.copy()
      params.update({"gamma": 0.3})
      zombie_plot(model_params=params)
```



infected are now divided into 2 waves

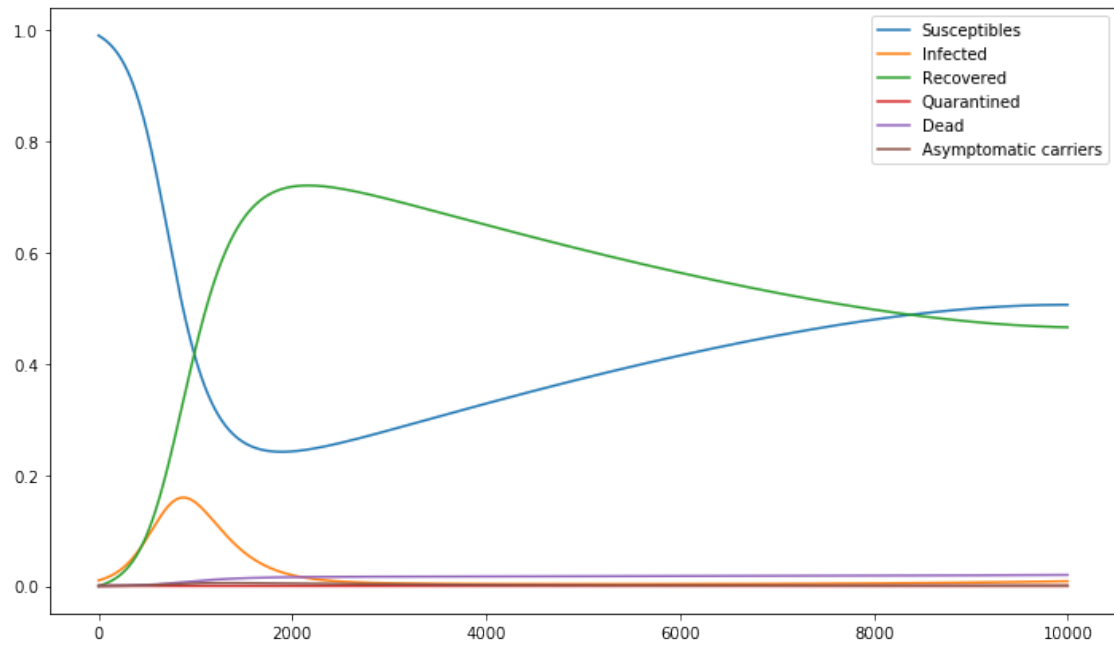
1.6 with everything

```
[9]: params = {  
    "alpha": 0.01,  
    "beta": 1,  
    "gamma": 0,  
    "zeta": 0.5,  
    "mu": 0.01,  
    "nu": 0.01,  
    "tau": 0.03,  
}  
zombie_plot(model_params=params)
```



```
[10]: params = {  
    "alpha": 0.01,  
    "beta": 1,  
    "gamma": 0,  
    "zeta": 0.5,  
    "mu": 0.01,  
    "nu": 0.01,  
    "tau": 0.05,  
}
```

```
zombie_plot(model_params=params)
```



even if the number of AC is small, the outcome is sensible to there immune capacity.

[]: