Nash's equilibrium

or when to get sick during a pandemic

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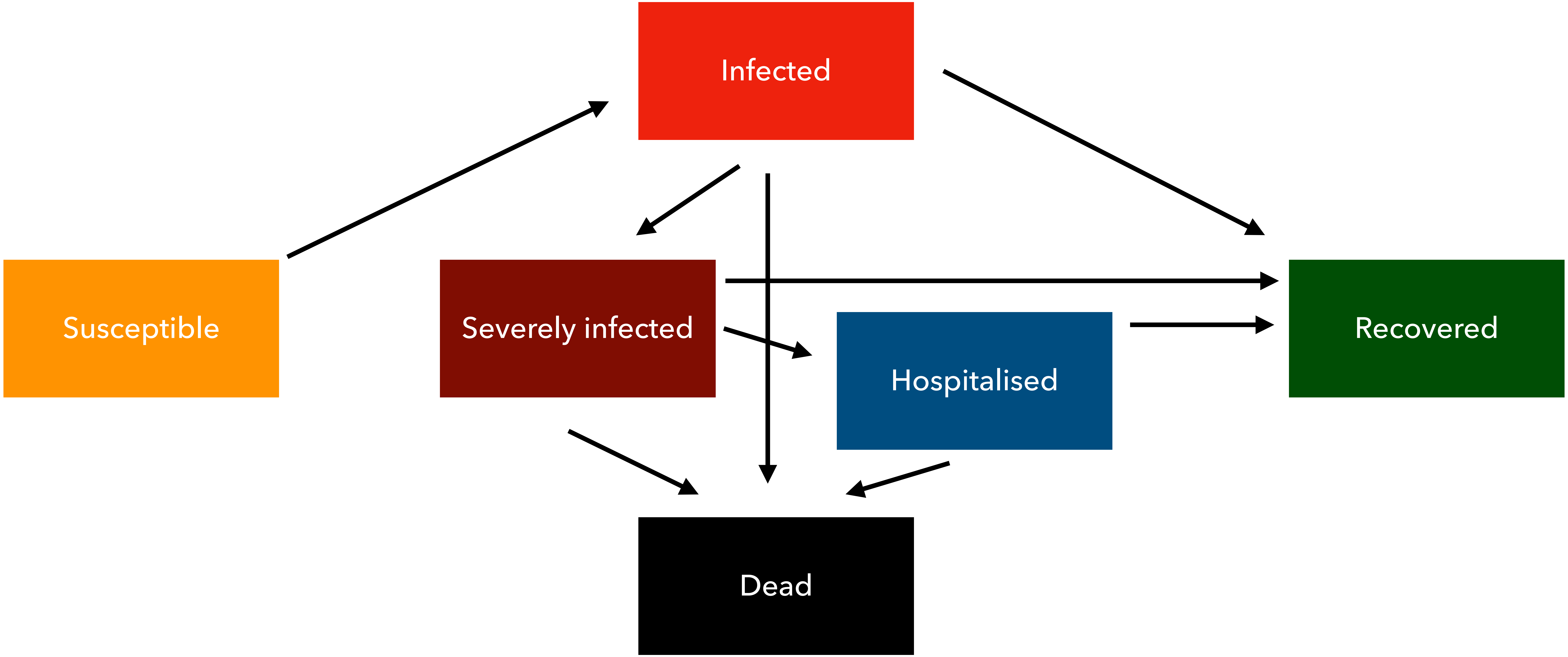
Pandemic characteristics

- Virus spread
  - Dependent on human carriers
  - Can be artificially reduced through reduced contact (social distancing) and hygienic behaviour

  → individual level actions
  - Influence by seasonality (elevated during winter)
  - Diminishes with share of immunised individuals
- Hospital care
  - Severely sick patients have better health outcomes through hospital care
  - Capacity issues do not allow for all severely sick patients to be treated
- Indirect effects of containment
  - Death rate is a bad metric for health benefits
  - Stress, depression and mental health concerns are very important with regards to containment considerations

Simulation states for agents



Agents in the game

Two types of agents

- Passive agent: $a^{(1)}(t) = a^{(1)}$

- Dynamic agent: $a^{(2)}(t) = \begin{cases} \mathit{risky} & \text{if risk conditions fulfilled} \\ \mathit{low\text{-}risk} & \text{otherwise} \end{cases}$

Conditions for behaviour

- Dependent on overall pandemic situation
- Important metric: hospital capacity c_t

$$a^{(2)}(t) = \begin{cases} \mathit{risky} & \text{if } c_t < 0.5 \cdot C \\ \mathit{low\text{-}risk} & \text{otherwise} \end{cases}$$

Infection rate dependent on infected (I), severely infected (SI), recovered (R) and susceptible (S), with higher rate for agent 2 individuals, if they decide to engage in infection

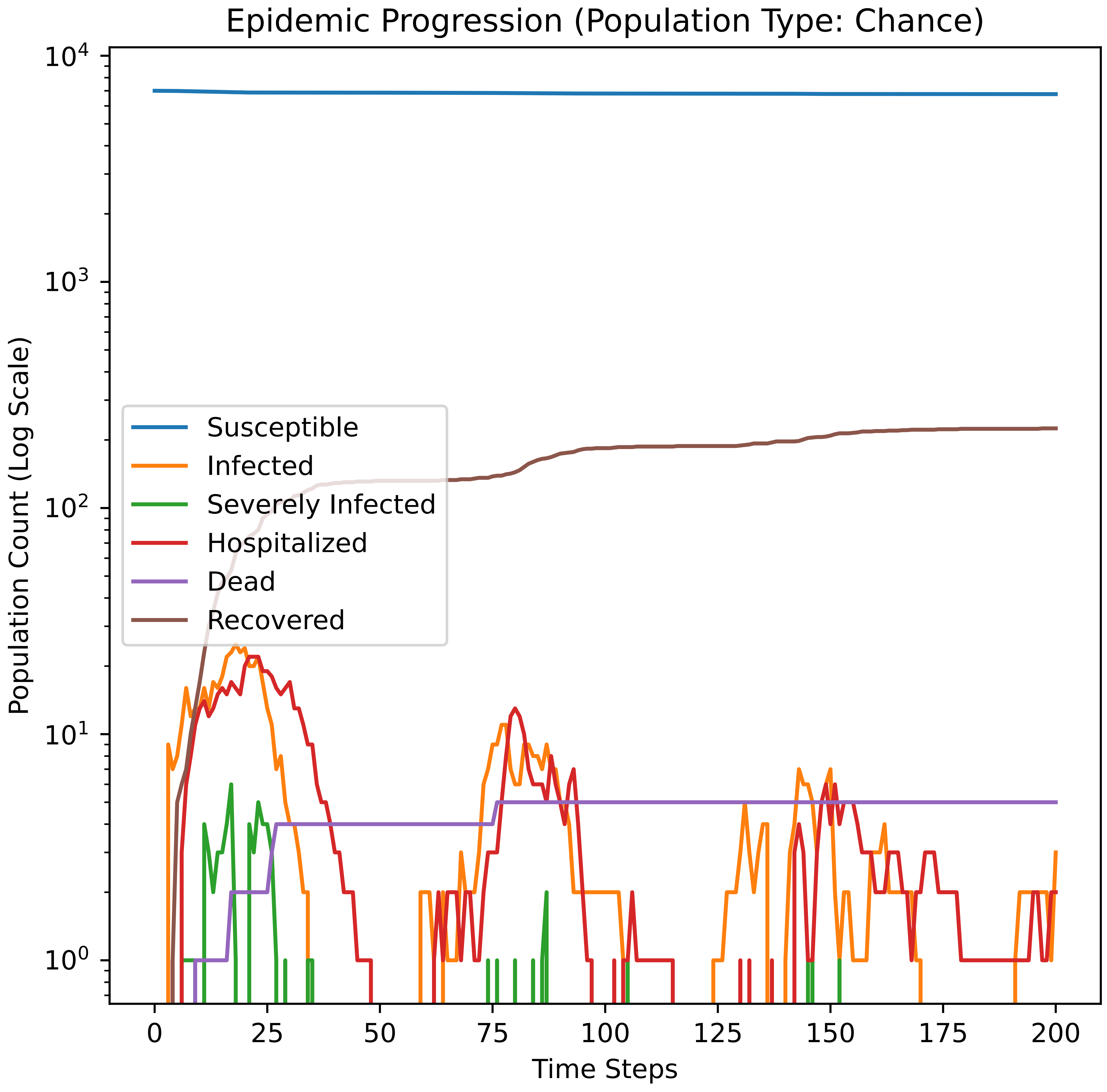
$$p^{(1)}(t) = z(t) \cdot \left(1 + \frac{\#I_t + \#SI_t}{\#S_t + \#I_t + \#SI_t + \#R_t}\right) \cdot \left(1 - \frac{\#R_t}{\#S_t + \#I_t + \#SI_t + \#R_t}\right)^{w_r}$$

$$p^{(2)}(t) = \begin{cases} f \cdot p^{(1)}(t) & \text{if } a^{(2)}(t) = \mathit{risky} \\ p^{(1)}(t) & \text{otherwise} \end{cases}$$

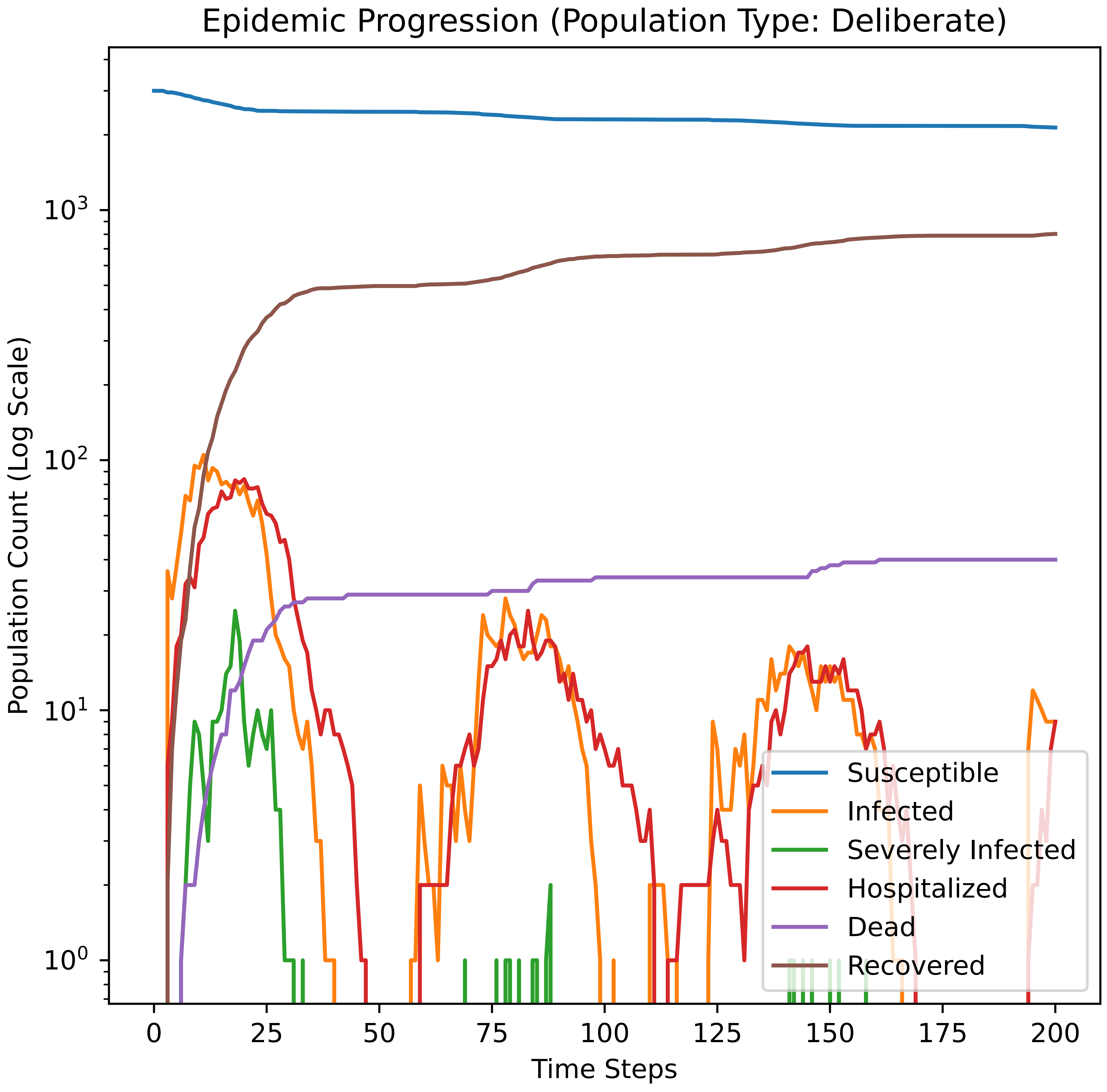
Distinguishing features

- Action space awareness
  - Two distinct set of groups, where one does not realise the possibility to take action and plays passively against the other group
  - Based on Keynesian hand-to-mouth consumer idea, with passive group as law-abiding citizens
- Hospitalisation extension
  - Hospitals as a way of making the pandemic more bearable
  - Need to be smoothed over, as supply of health care is inelastic
- Self interest for type 2 agents
  - Own health outcome is only one of several self-focussed objectives type 2 agents attempt to achieve
  - No regards for primary, passive group

Results – 1



Epidemic Progression (Population Type: Chance)
Population Count (Log Scale)
Time Steps
Susceptible
Infected
Severely Infected
Hospitalized
Dead
Recovered



Epidemic Progression (Population Type: Deliberate)
Population Count (Log Scale)
Time Steps
Susceptible
Infected
Severely Infected
Hospitalized
Dead
Recovered

Results – 2

- Dynamic group suffers from higher death rates regardless of hyper-parameters

- Socially beneficial results can be achieved, as seen in the table
  - Upper row reflects base case with no dynamic group, where death rate is 0.7%
  - Lower row reflects two group model, where the overall death rate is 0.6%

Chance / Baseline	Deliberate
0.700%	nan
0.142%	1.666%

→ Social benefit of individual decision making for share of population

Conclusion

- Policy recommendations
    - More laissez-faire policies during summer months, when health-care capacities are available
    - Increased hospital capacity to smooth over more infections in less time
- Individual level results
    - More awareness of individual level decision making and revealed preferences between freedom and risk of death
    - Positive for rule adheres no matter the result for the dynamic group - passivity pays off (w.r.t death rate)
- Caveats
    - Data for hospitalisation and disease spread not readily available in a real pandemic
    - Reinfection not considered
    - Parameters need to be adjusted to fit exact real life values