Fear Effect on Epidemic Networks

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Aim

Visualize and quantify the effect of different types of fear on epidemic dynamics

- Attack rate vs R0
- Shape of Incidence, Death incidence vs t (we should see plateau-like behaviour)

How does the fear impact the epidemic dynamics?

Options

Kinds of networks:

- Homogeneous (Erdős - Rényi ER)
- Heterogeneous (Barabási - Albert BA)

Models of fear:

- No fear
- Random
- Based on prevalence of infected and deaths
    - Neighbours
    - Global

Compartmental models:

- SIRD1 = SIRD where only S have fear of getting infected
- SIRD2 = SIRD where both S and I have fear of getting infected and infecting respectively

Model

Parameters

β = infectious rate = 0.5

μ = recovery rate = 1/6

f_{d_min} = minimum fatality rate = μ/10

Data on β, μ are specifically chosen to model the COVID-19 epidemics (https://www.pnas.org/doi/full/10.1073/pnas.2009911117)

Basic Reproductive ratio:

$$R_0 = \frac{\beta}{\mu}\frac{\langle k^2\rangle - \langle k\rangle}{\langle k\rangle}$$

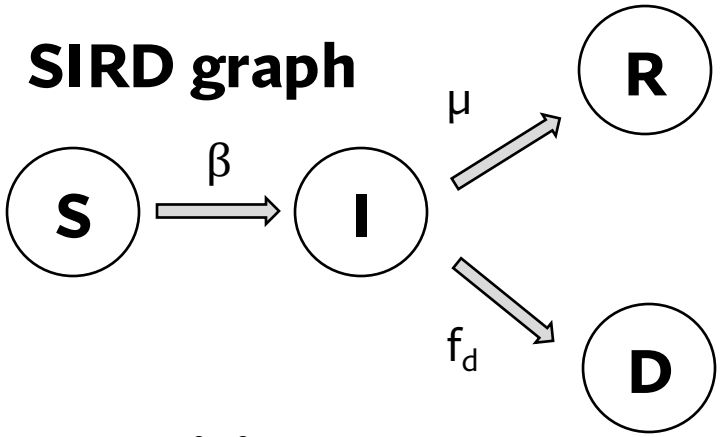
Network structure

N = # of nodes = 1000

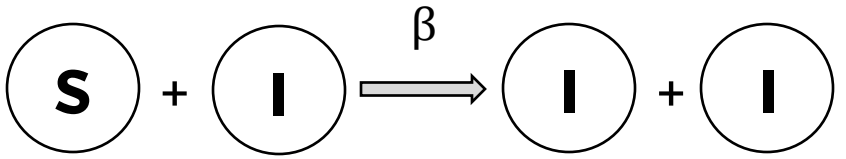
p = probability of connection = 0.01 (Erdős - Rényi)

m = # of links made at each step = 5 (Barabási - Albert)

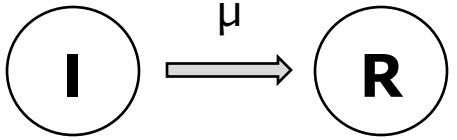
SIRD graph



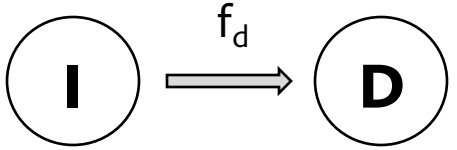
Transitions



Mediated transition



Spontaneous transition

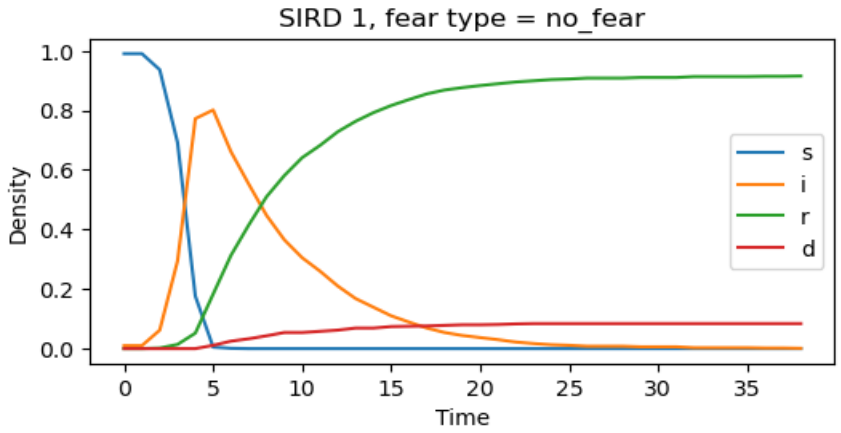


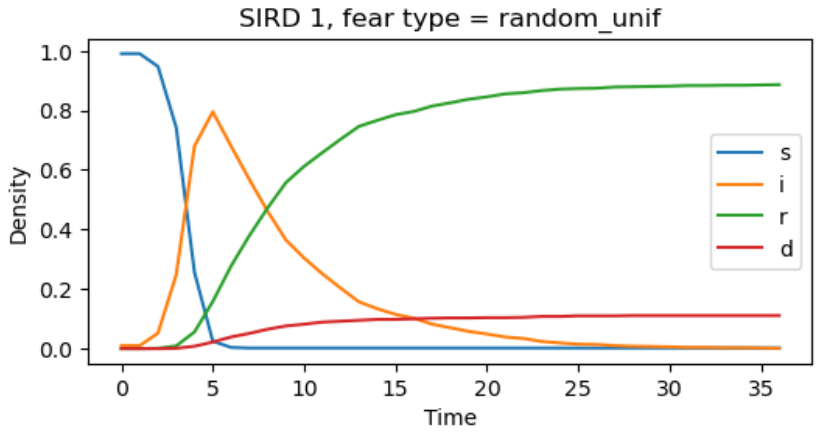
Spontaneous transition

Evolution of S,I,R,D

Erdős - Rényi SIRD with only susceptible have fear

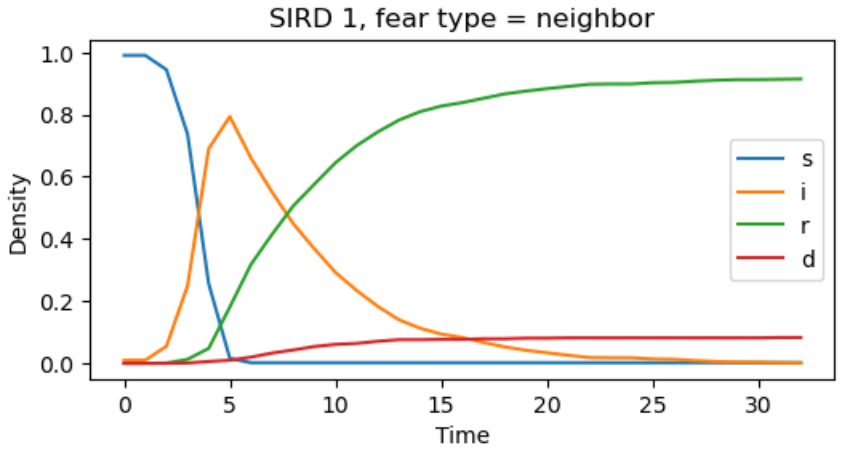
Cut edges = 0

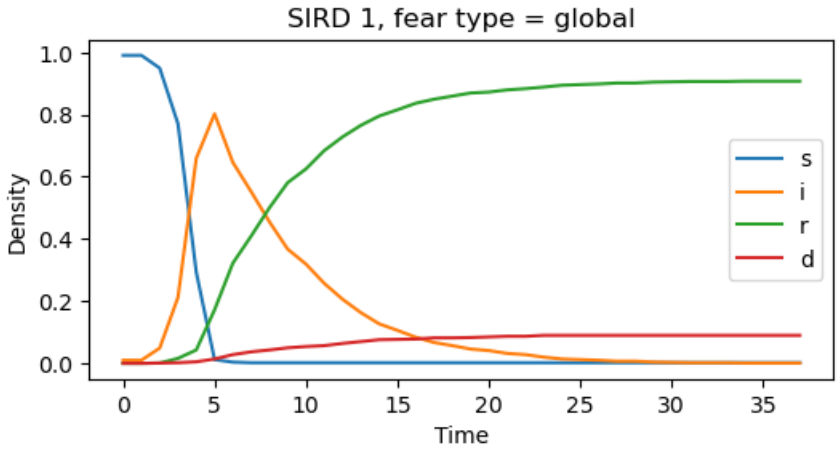




Cut edges = 1755

Cut edges = 1612





Cut edges = 422

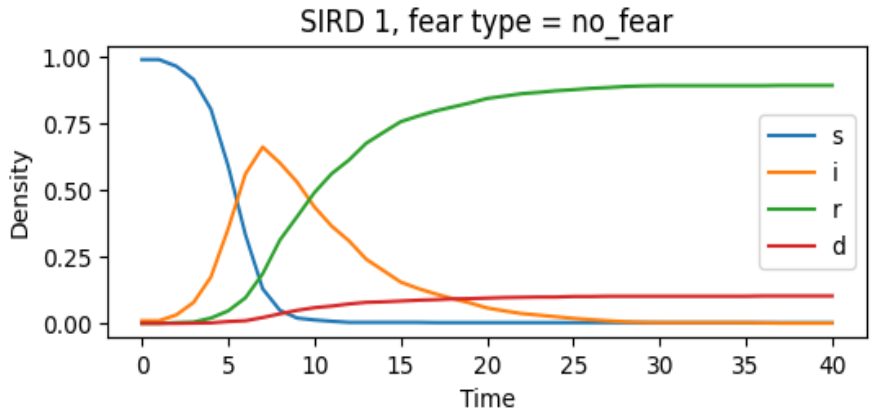
The same can be observed for SIRD with susceptible and infected feared and for Barabási-Albert

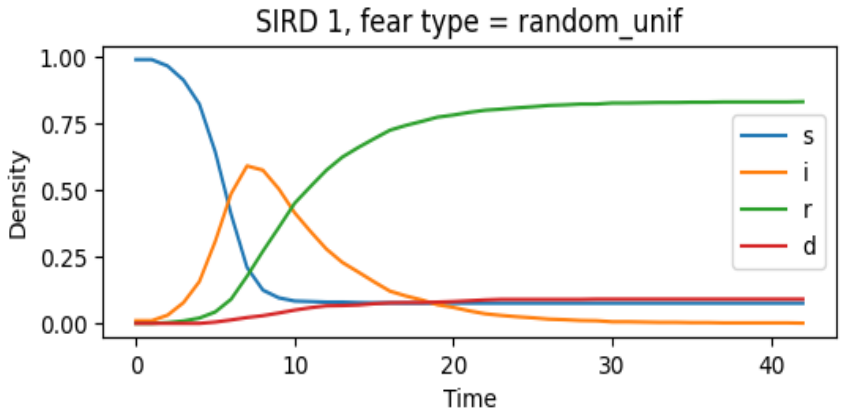
Evolution of S,I,R,D

Erdős - Rényi SIRD with only susceptible feared

Change infectivity rate to better appreciate the fear impact: **β = 0.2**

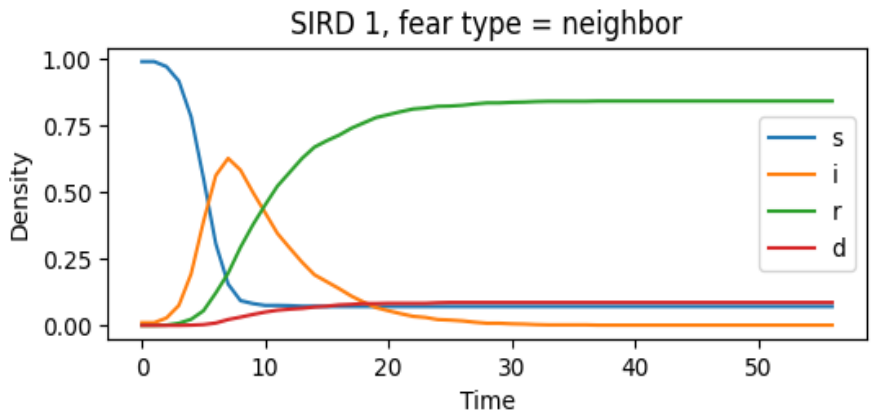
Cut edges = 0

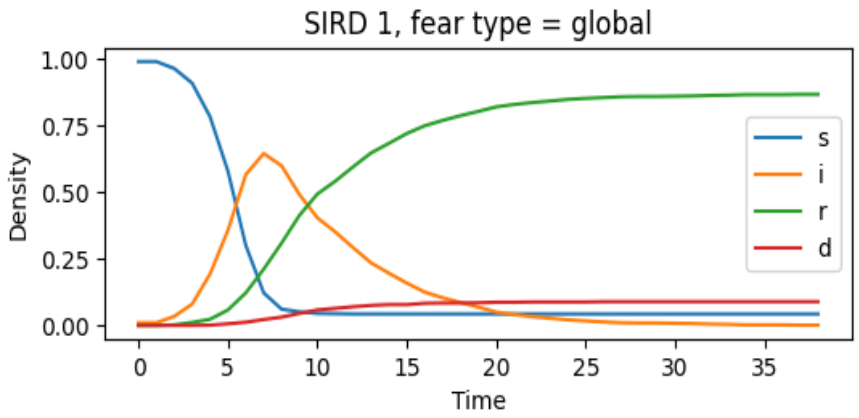




Cut edges = 2600

Cut edges = 2268





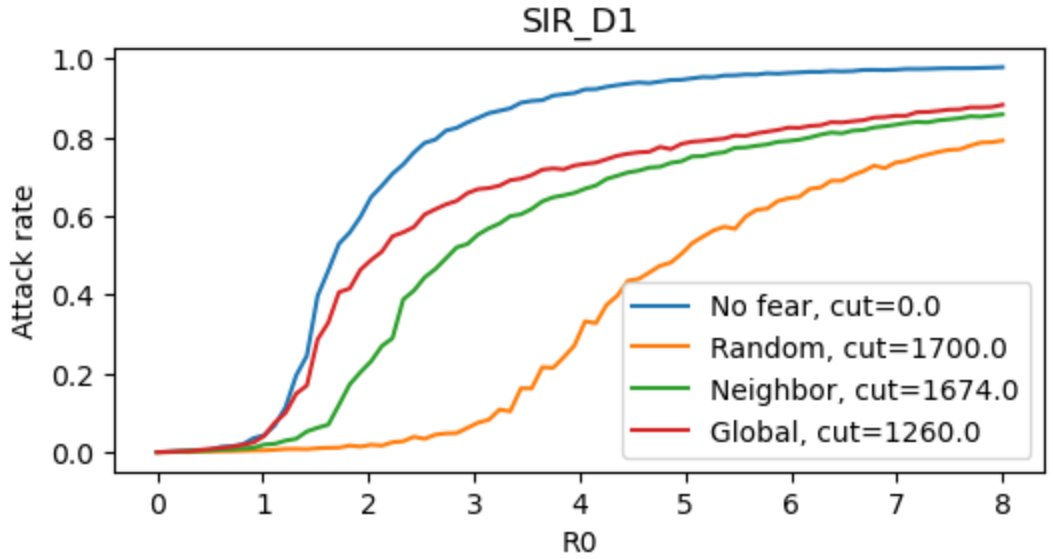
Cut edges = 1172

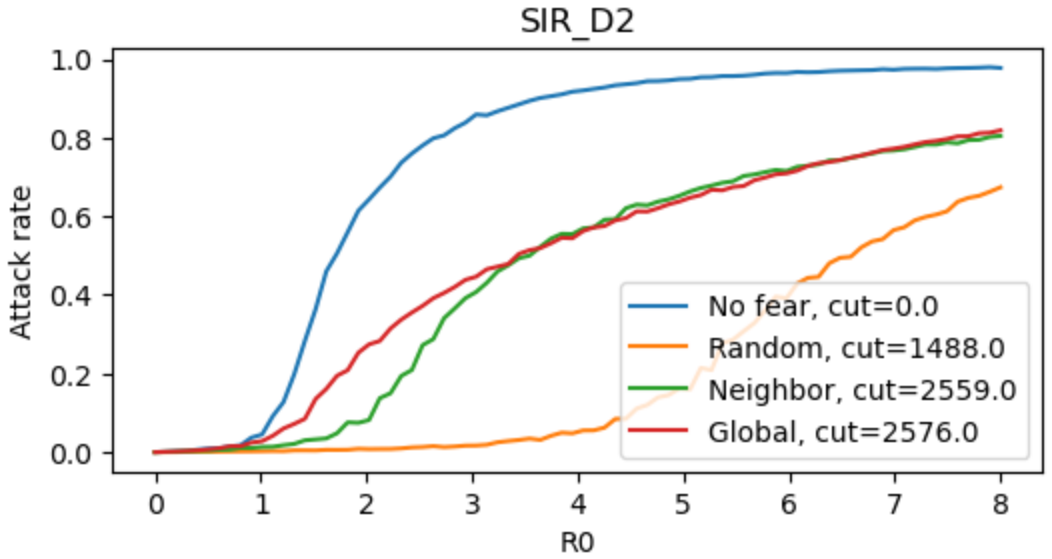
Results (I)

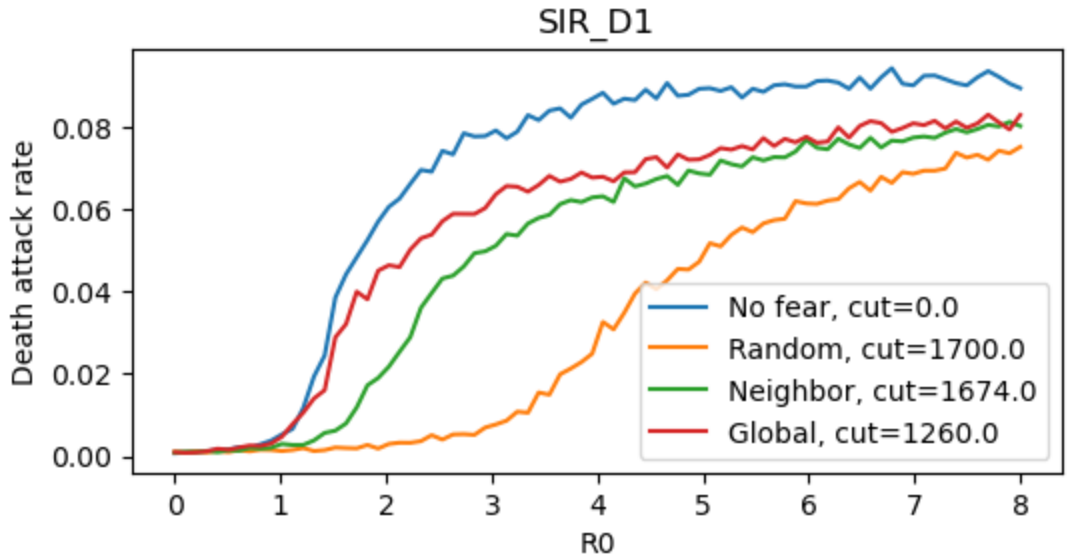
Attack Rate vs R_0

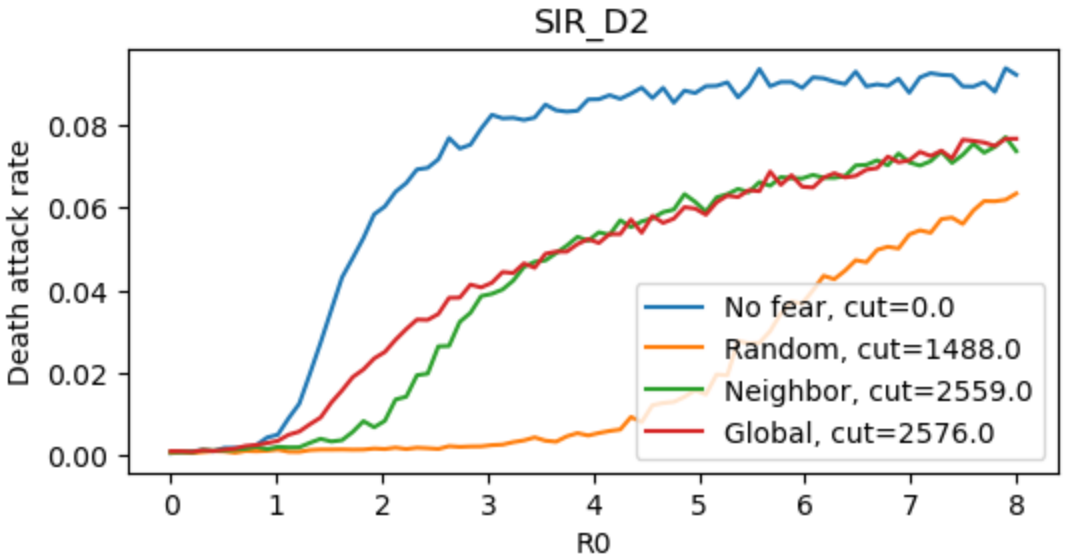
Comparison of results for the same model and different kinds of fear in the same graph

Erdős - Rényi


SIR_D1
Attack rate
R0
No fear, cut=0.0
Random, cut=1700.0
Neighbor, cut=1674.0
Global, cut=1260.0


SIR_D2
Attack rate
R0
No fear, cut=0.0
Random, cut=1488.0
Neighbor, cut=2559.0
Global, cut=2576.0


SIR_D1
Death attack rate
R0
No fear, cut=0.0
Random, cut=1700.0
Neighbor, cut=1674.0
Global, cut=1260.0


SIR_D2
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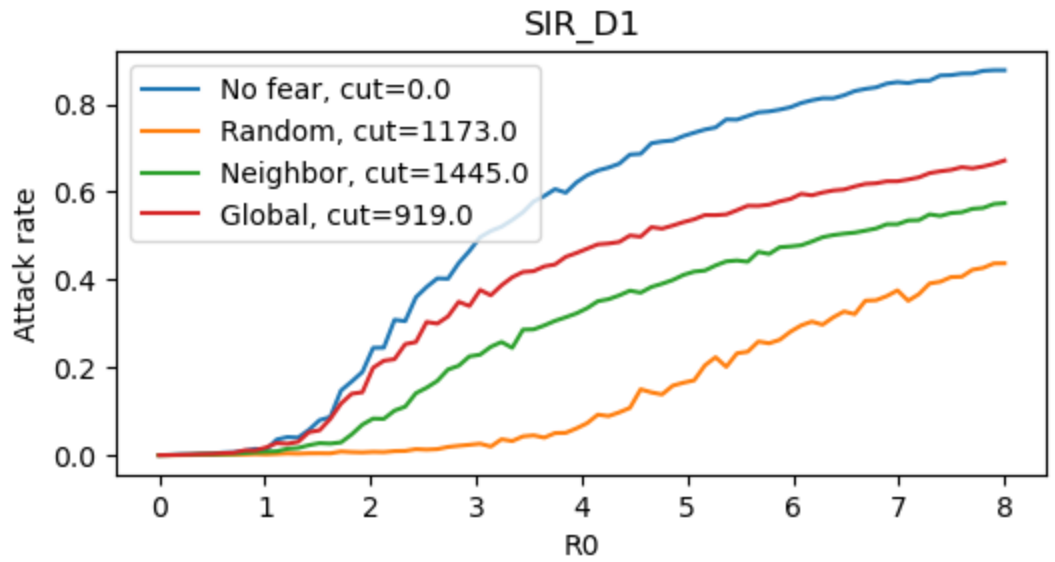
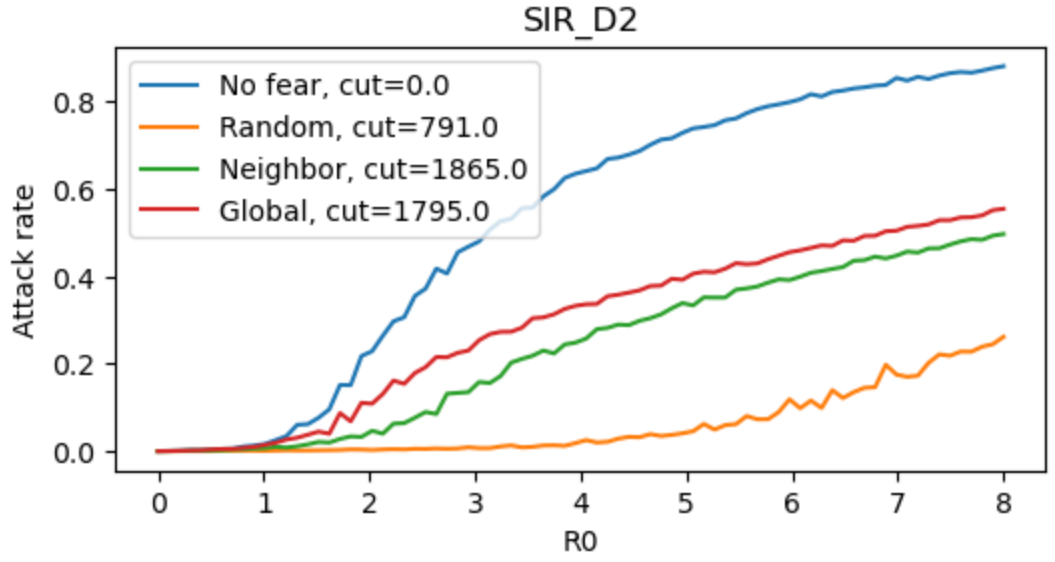
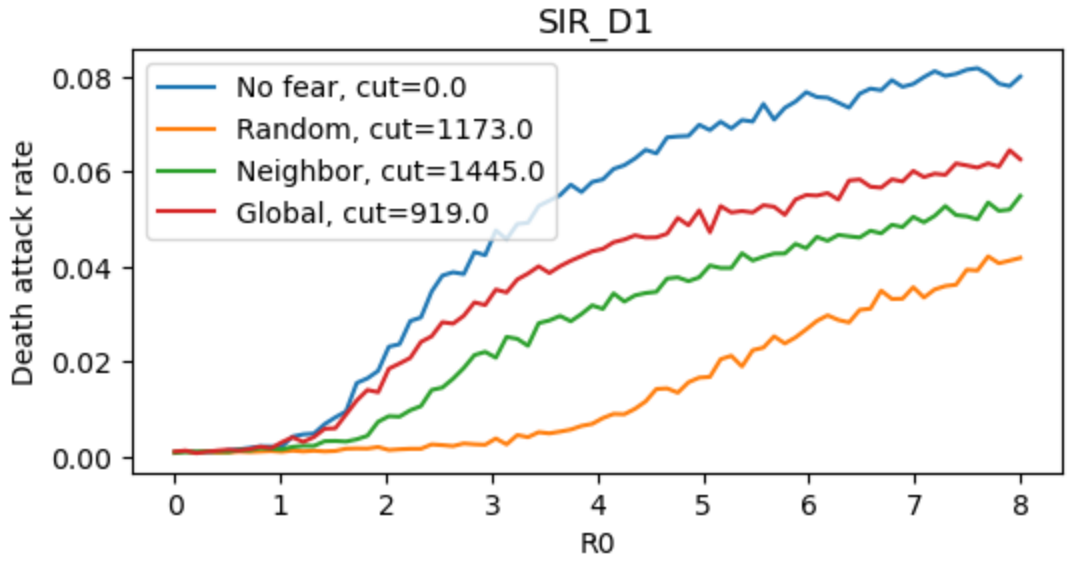
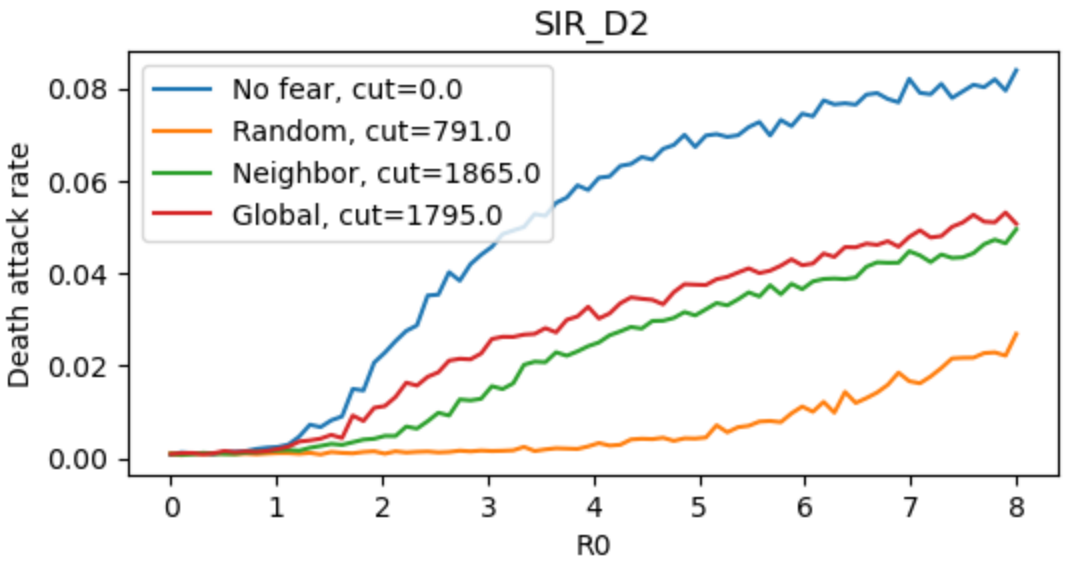
Barabási - Albert







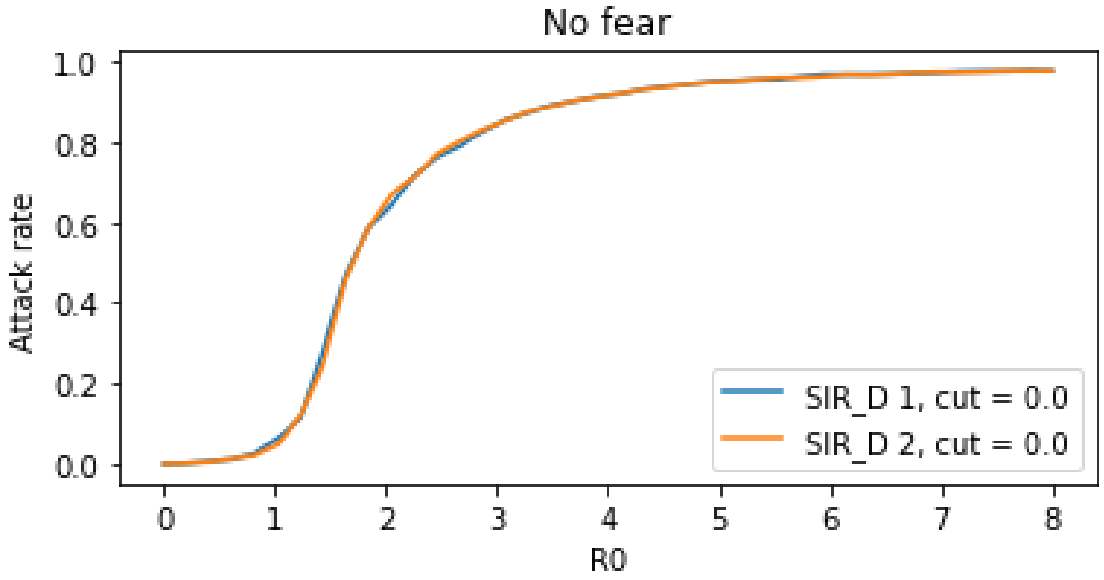


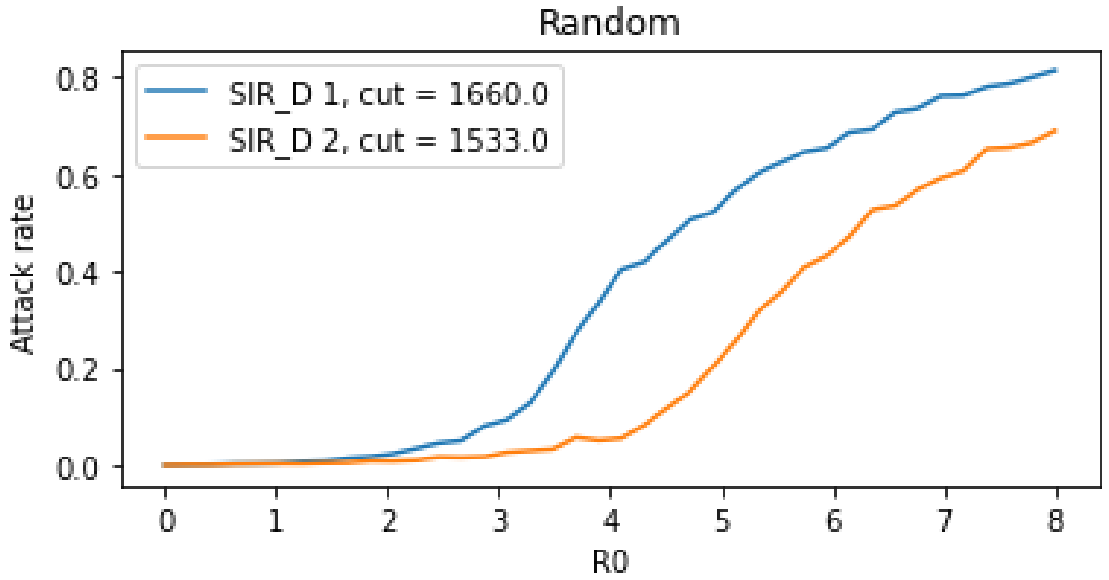
Results (II)

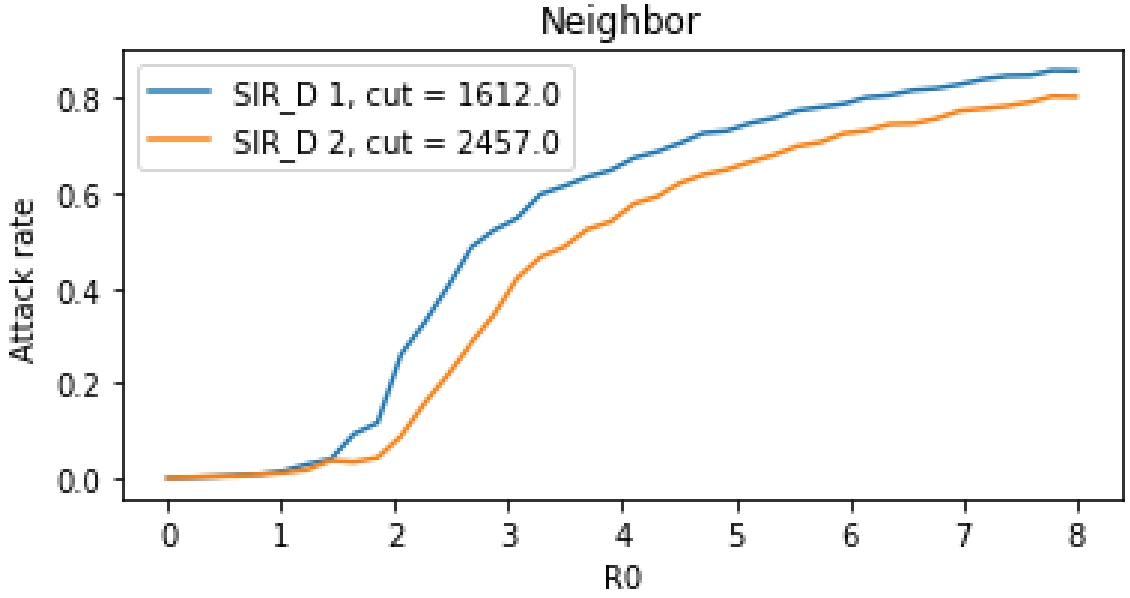
Attack Rate vs R_0

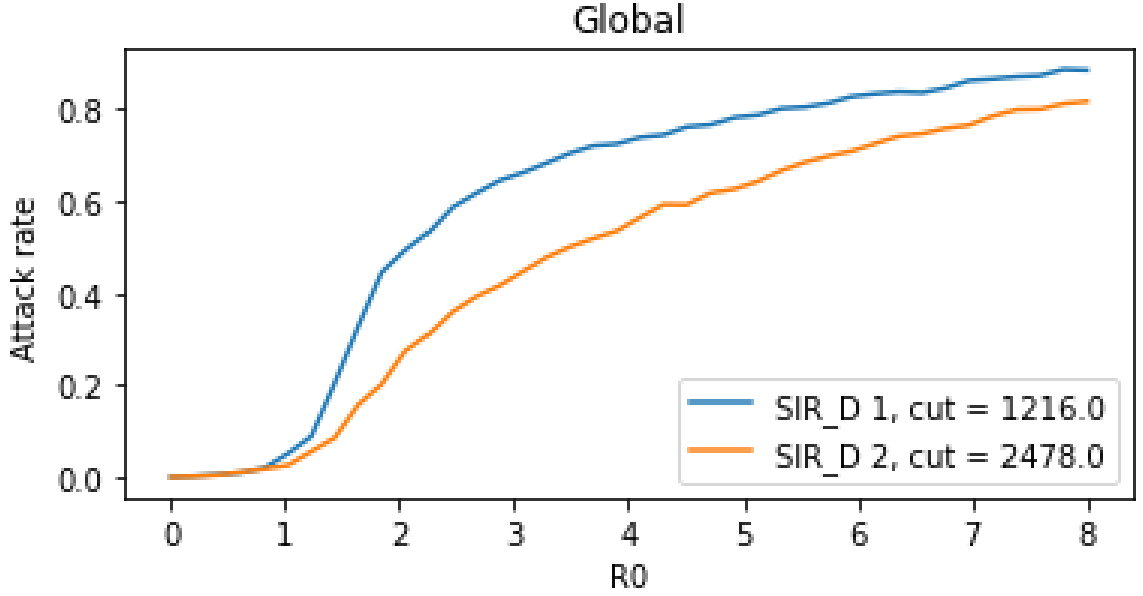
Comparison of results for different models and same kind of fear in the same graph

Infected individuals Erdős - Rényi

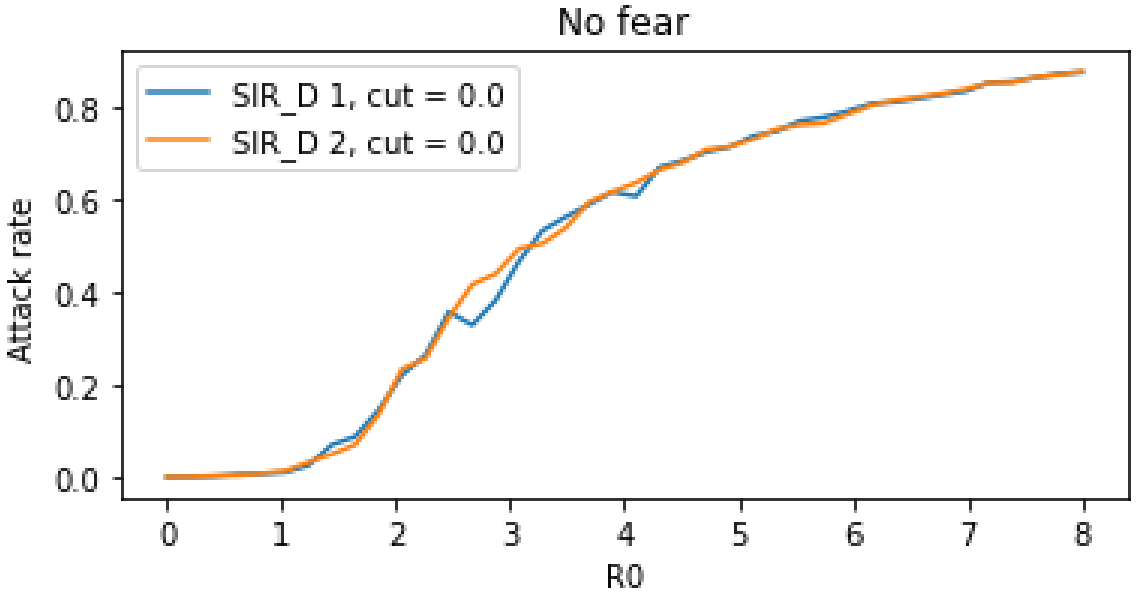


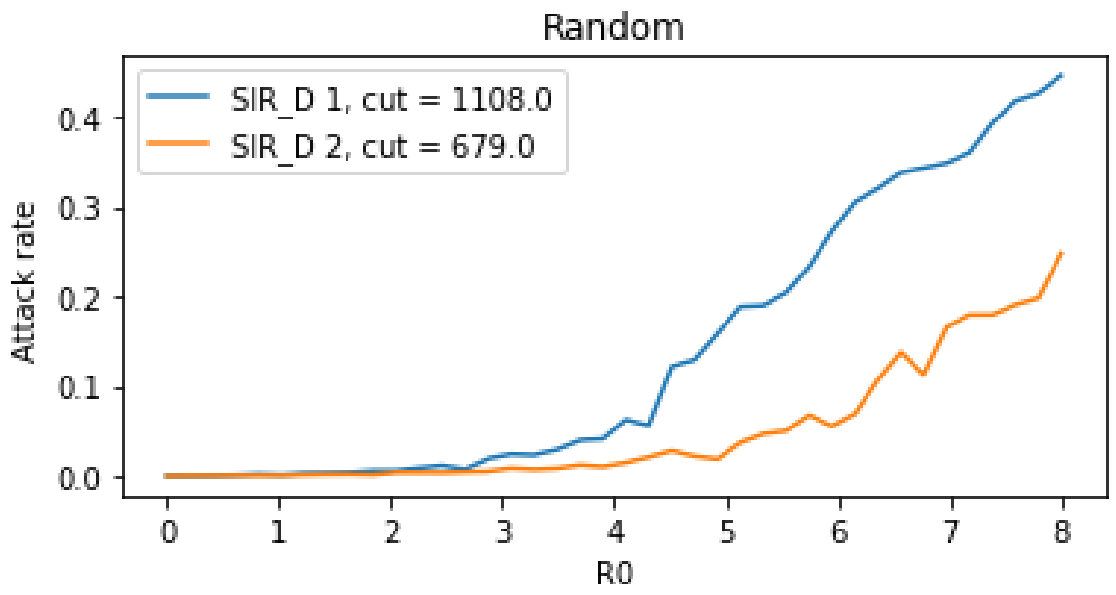


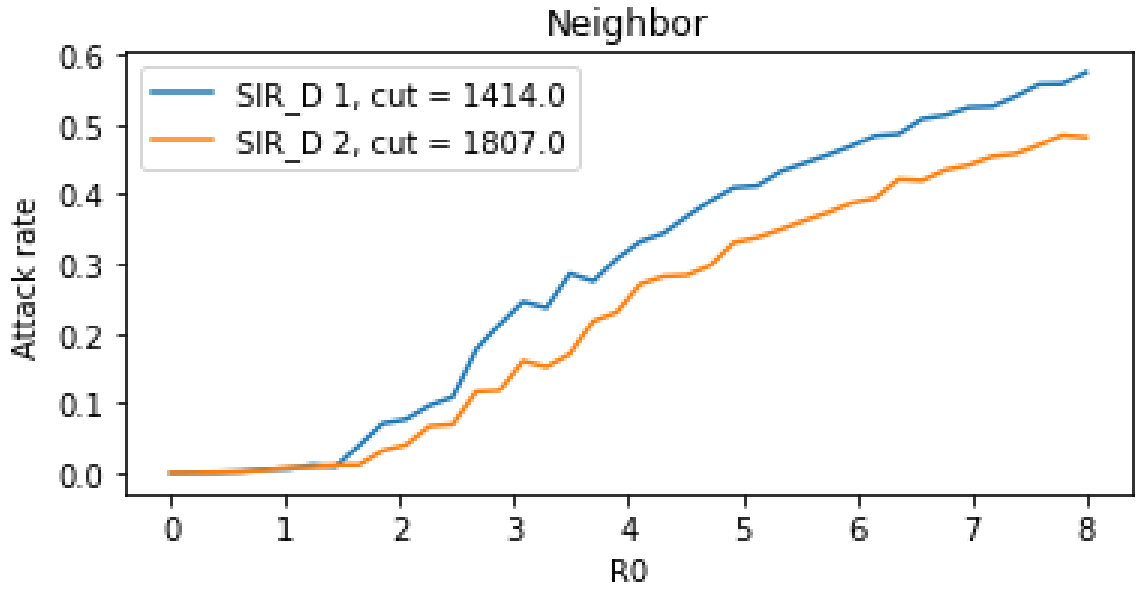


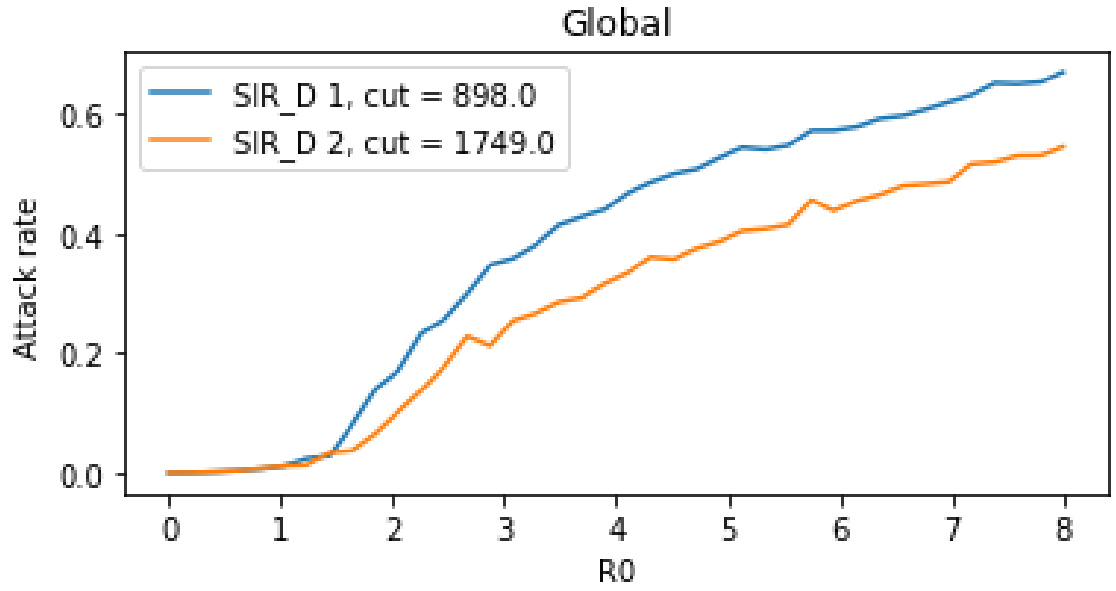


Infected individuals Barabási – Albert







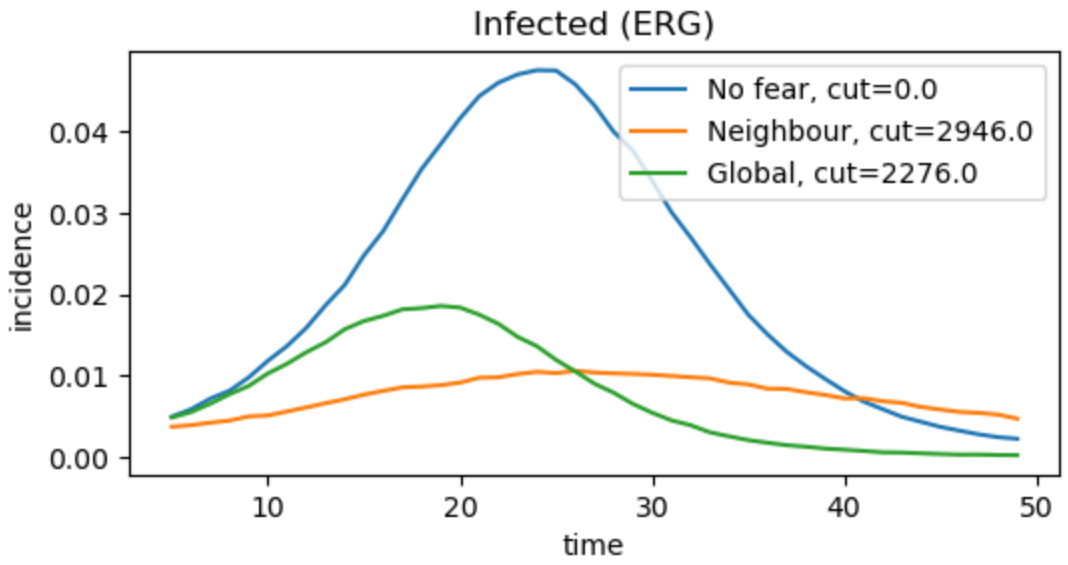


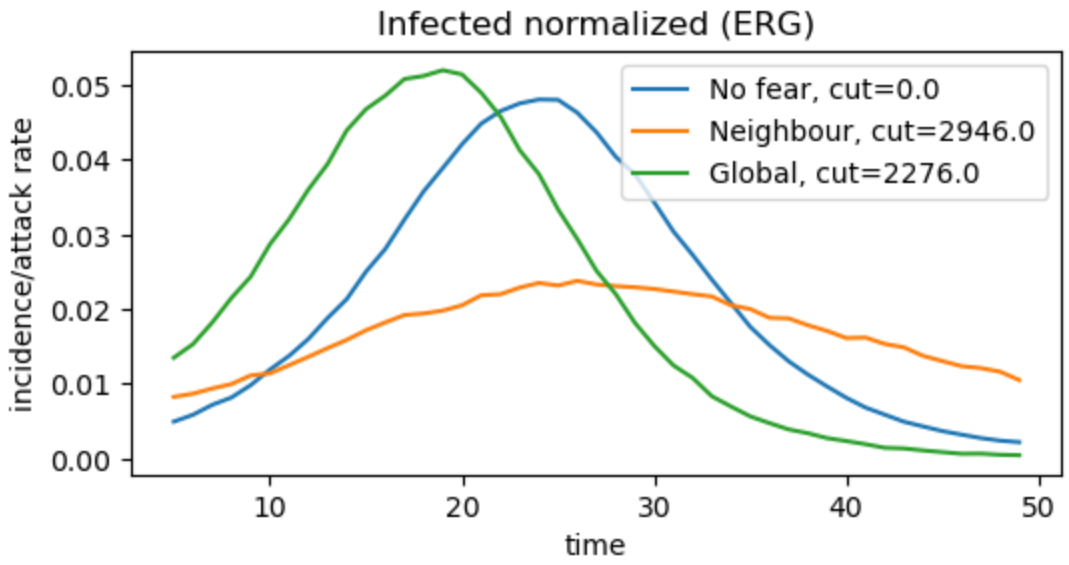
Results (III)

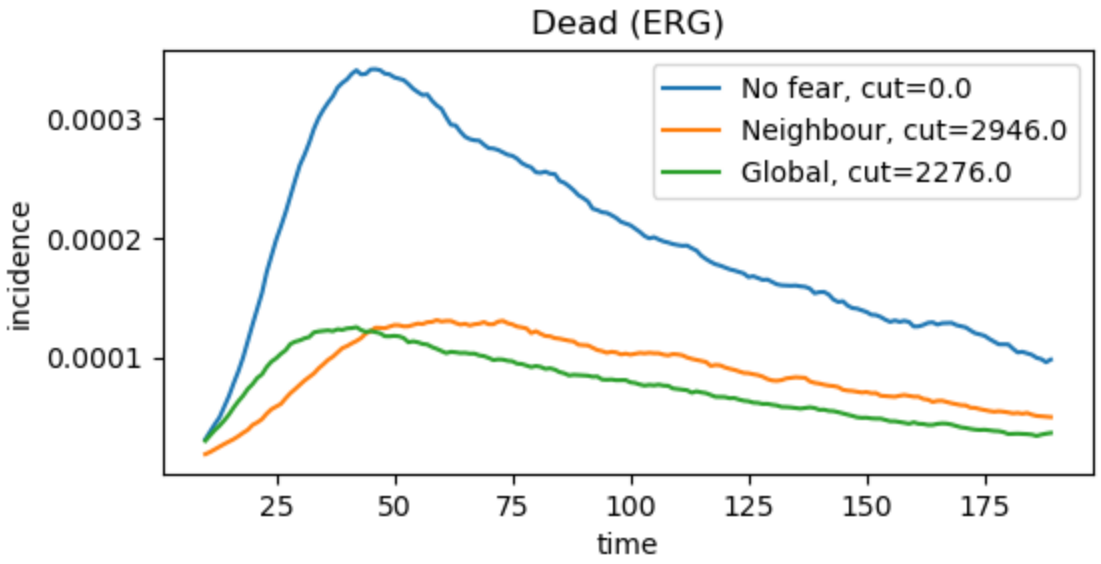
Incidence vs Time

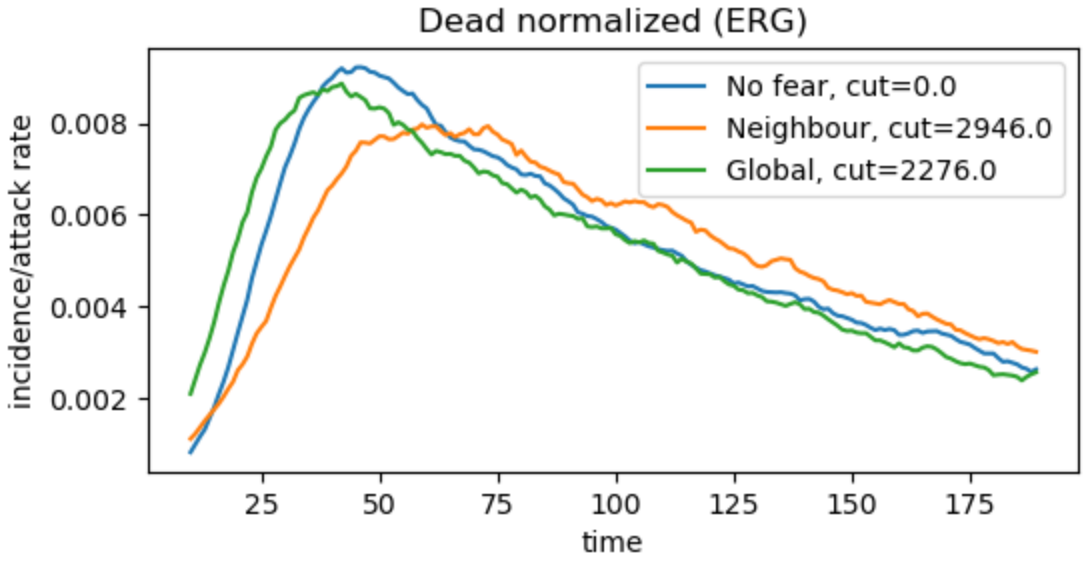
How does the fear affect the **SHAPE** of the dynamics?

SIRD1, Erdős – Rényi

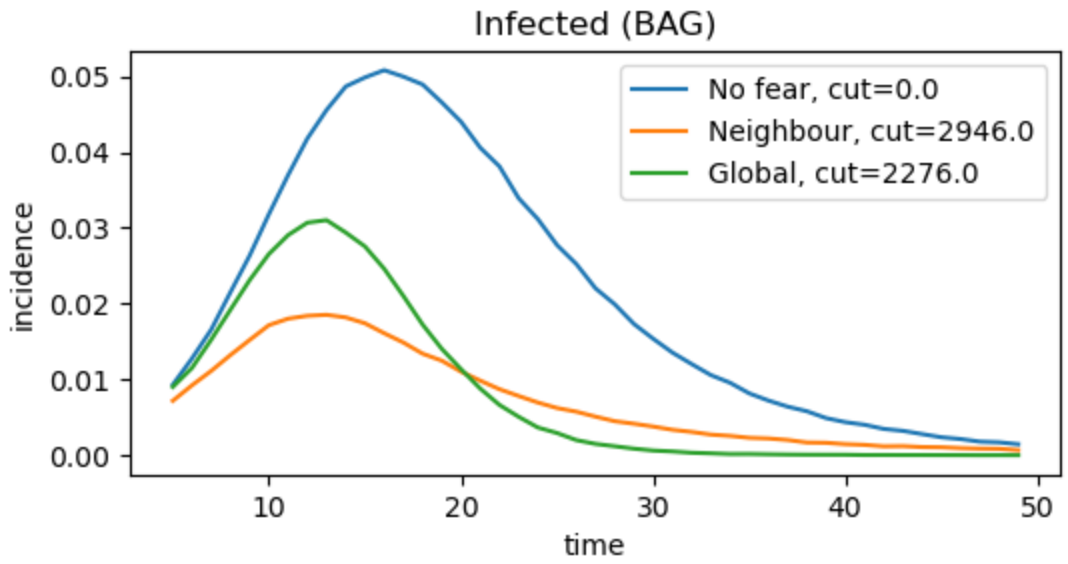


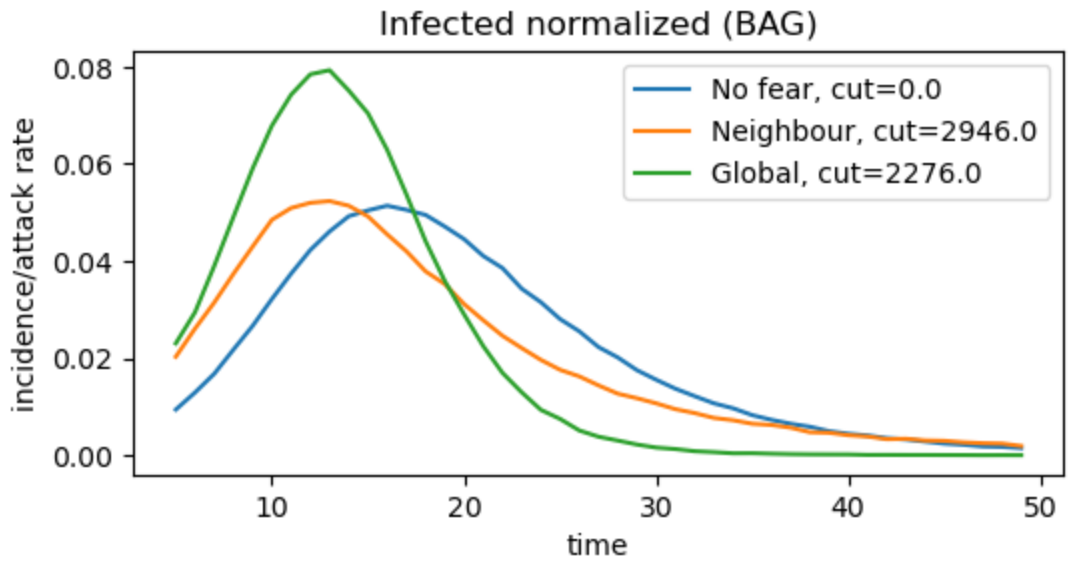


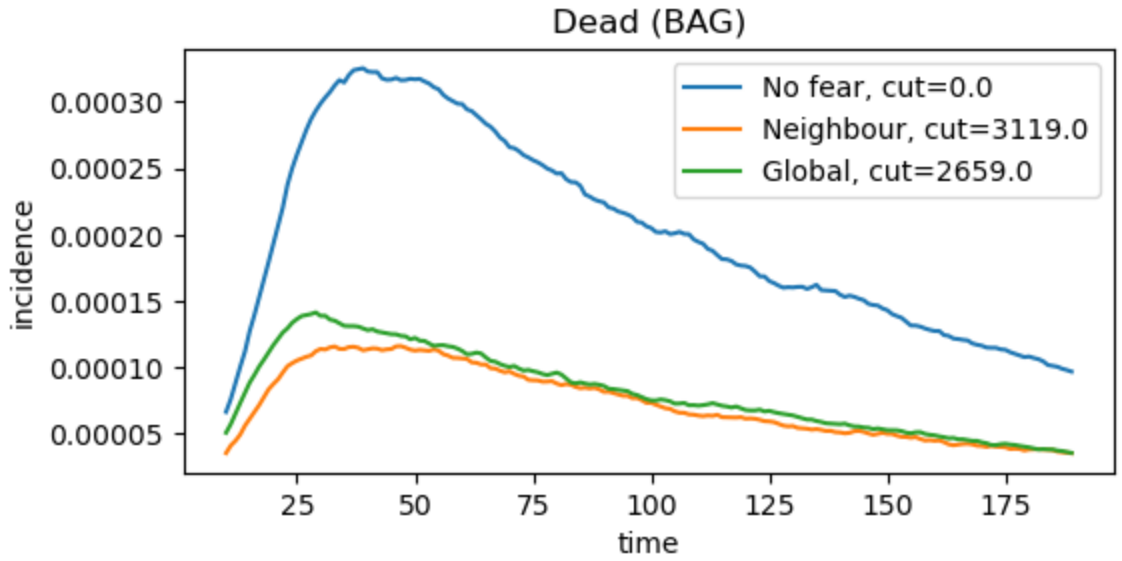


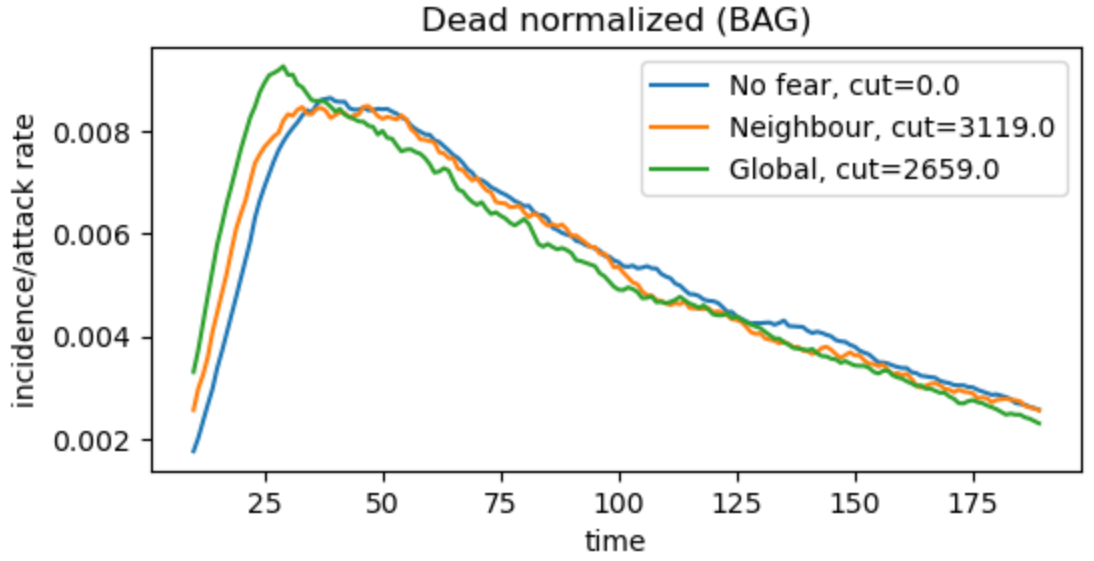


SIRD1, Barabási - Albert

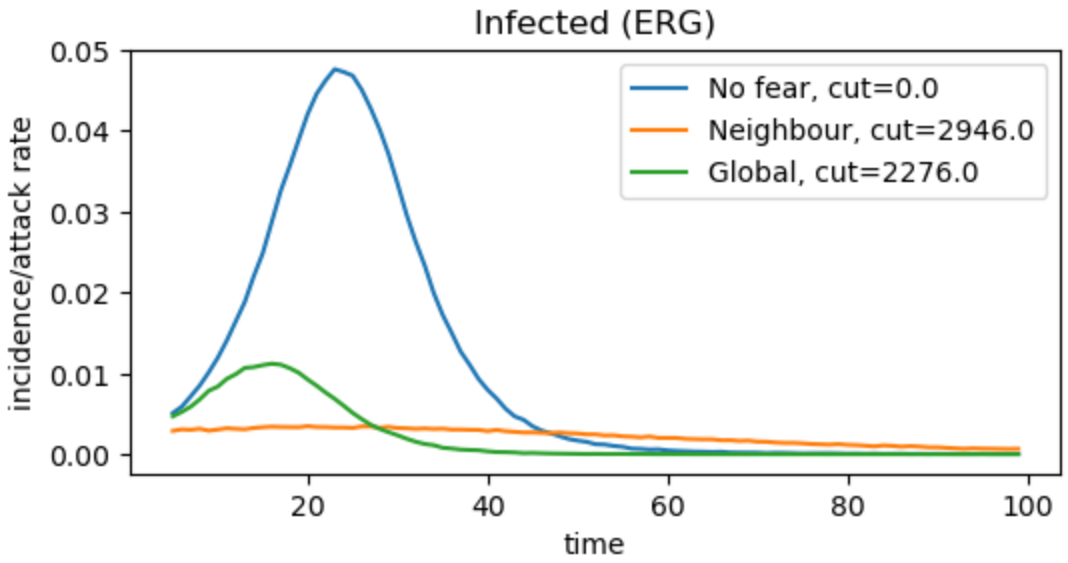


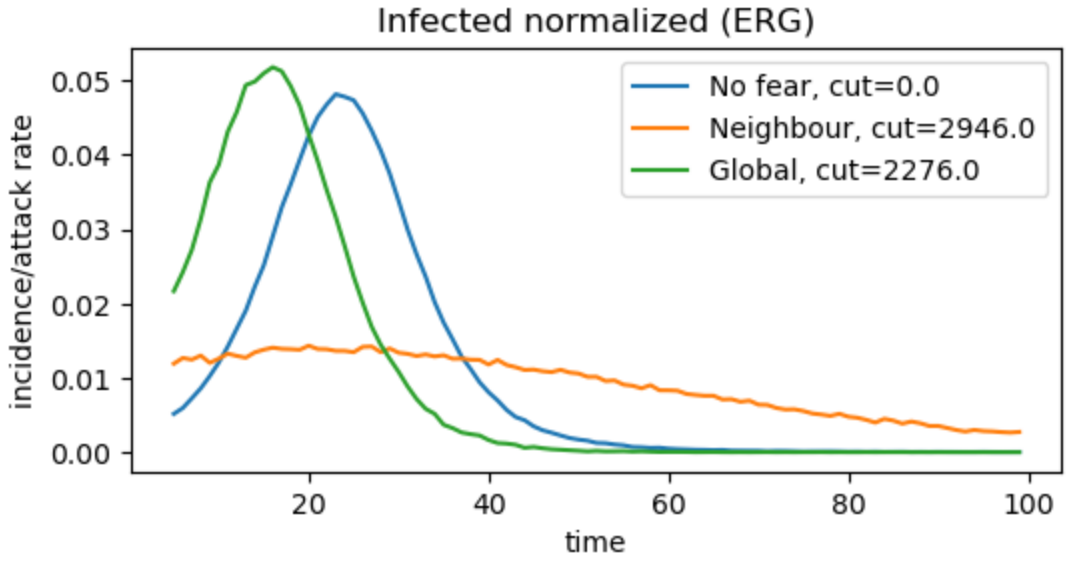


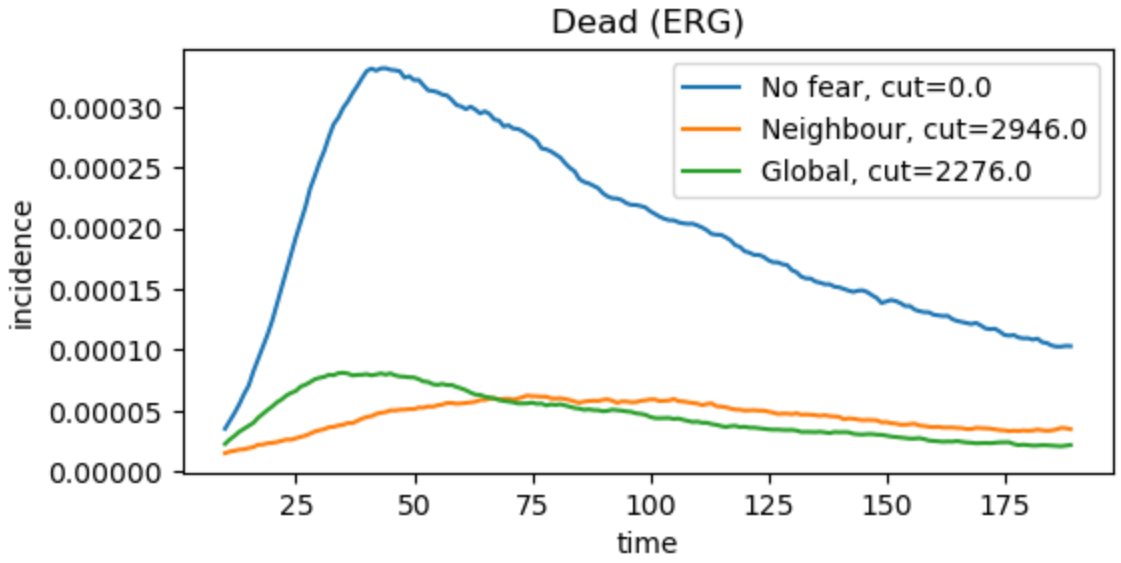


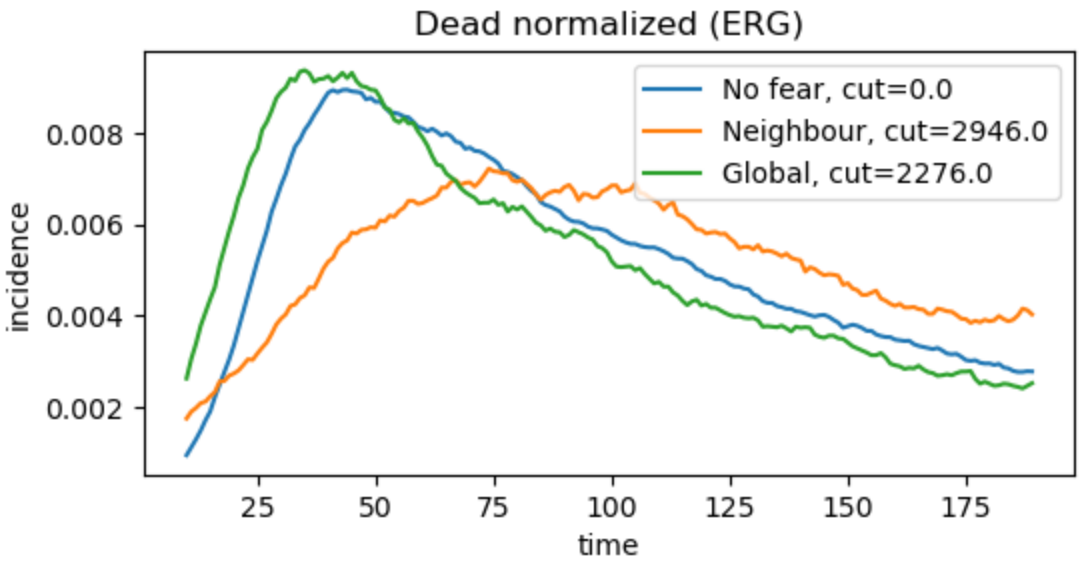


SIRD2, Erdős – Rényi

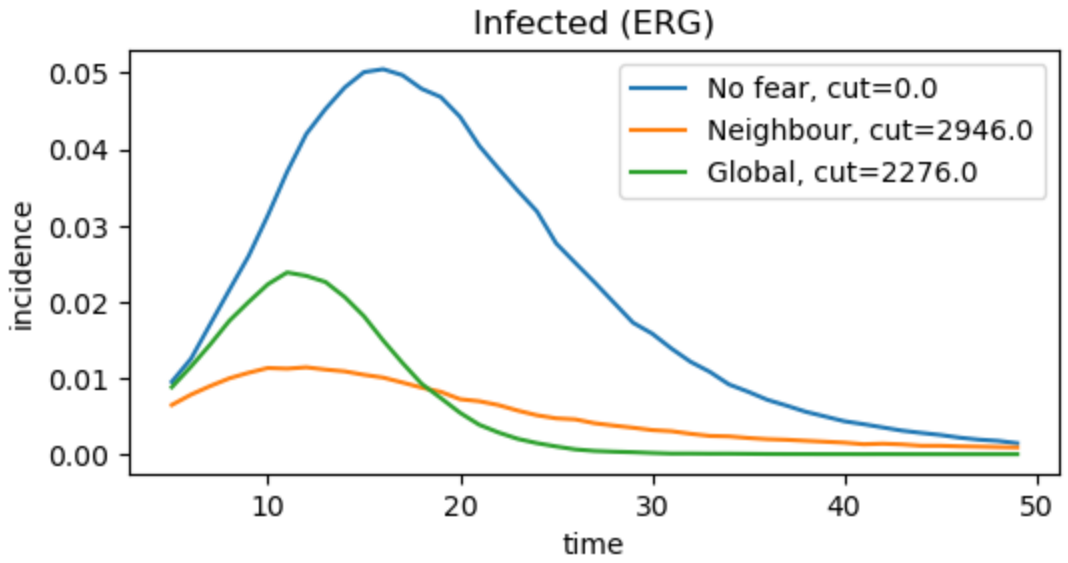


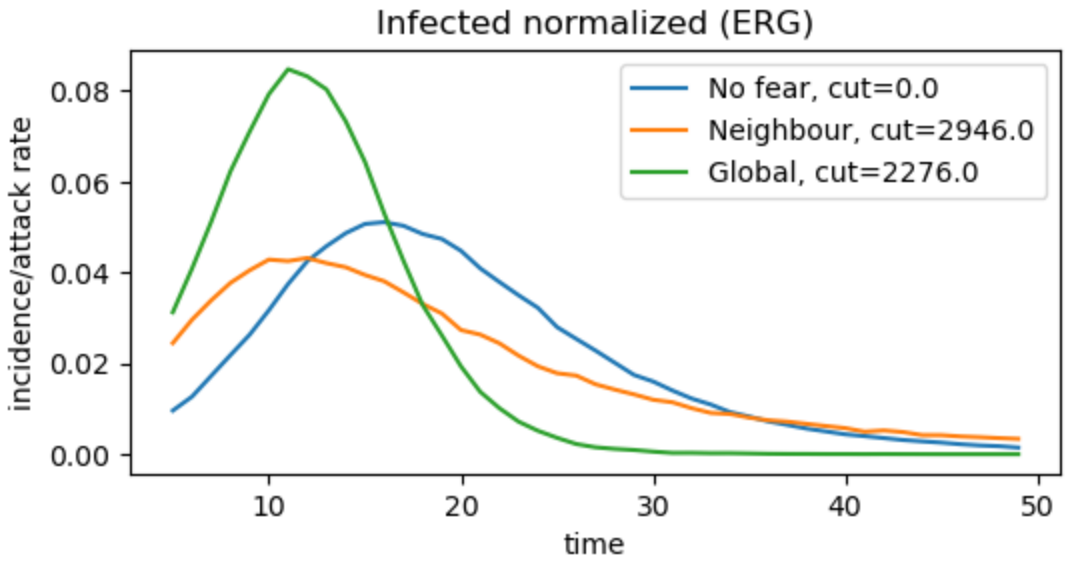


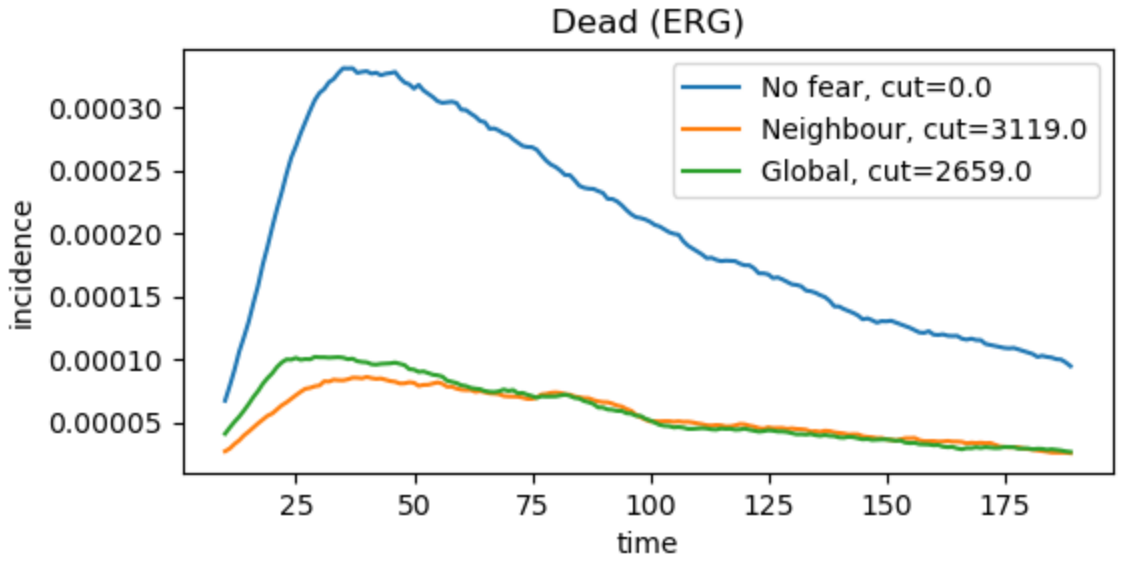


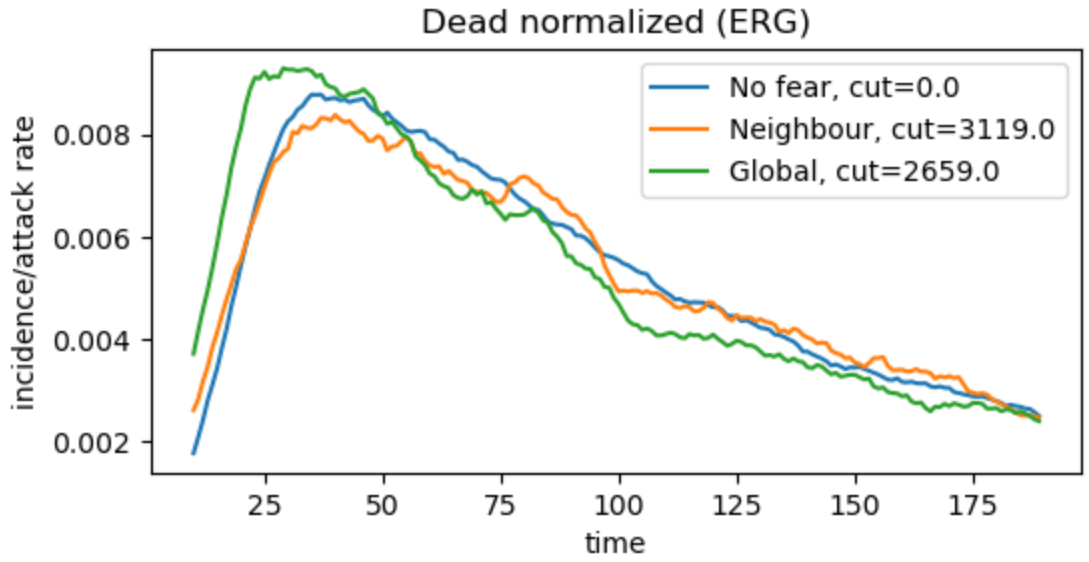


SIRD2, Barabási - Albert









Conclusion

-We can conclude that the **fear** has an **impact** on the epidemic spreading:

-The most effective approach is the fear based on the **neighbours** of the nodes since it is more localized

Thanks