HW4

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PART A - Epidemic Spread

b. Analyse the spread of an epidemic using epidemic analysis function over the the networks G1(epidemic1) and G2(epidemic2) with 50 simulations for each network:

G1:

```
--- G1 ---
Setting A
{'infections_total': 645.5, 'infectious_current': 25.66, 'mortality_total': 165.0, 'r_0': 0.11485068367416601}
Setting B
{'infections_total': 516.7, 'infectious_current': 36.78, 'mortality_total': 237.92, 'r_0': 0.0793966550363584}
Setting C
{'infections_total': 235.3, 'infectious_current': 0.0, 'mortality_total': 79.02, 'r_0': 0.0}
Setting D
{'infections_total': 322.96, 'infectious_current': 0.08, 'mortality_total': 180.46, 'r_0': 0.0}
```

G2:

```
--- G2 ---
Setting A
{'infections_total': 1254.74, 'infectious_current': 17.36, 'mortality_total': 372.28, 'r_0': 0.07818880676126398}
Setting B
{'infections_total': 977.9, 'infectious_current': 28.6, 'mortality_total': 505.72, 'r_0': 0.04281628808921709}
Setting C
{'infections_total': 653.0, 'infectious_current': 0.0, 'mortality_total': 230.86, 'r_0': 0.0}
Setting D
{'infections_total': 759.58, 'infectious_current': 0.0, 'mortality_total': 437.44, 'r_0': 0.0}
```

Conclusion for how the different parameters affect the population health:

we can see that when we use the SIS model we get bigger infections total and bigger mortality total, that by using the SIR model. It's make sense because in the SIS model nodes get sick, recover and that can get sick again, in the SIR model when nodes recover they can’t get sick again, so by using the SIS model we can get more infections as nodes can get sick more than one time. Its affect also the mortality numbers, as when nodes are sick they can die, so by being sick more times their period of time where they can die increase, and that increase their chances to die.

We also can see that when we increase the p parameter (chance to get infected by the disease) and the infection time we get bigger mortality total. by using the SIS model we get lower total infections, and by using the SIR we get bigger total infections.

Its make sense to get bigger mortality total number as if people are sick for longer time their chances to die from the disease are increased by every day they sick.

PART B - Vaccination Policy

b. Analyse the spread of an epidemic using vaccination analysis function over the the networks G1(epidemic1) and G2(epidemic2) with 50 simulations for each network:

G1:

```
--- G1 ---
Setting A - Random Policy
{'infections_total': 657.82, 'infectious_current': 13.62, 'mortality_total': 216.84, 'r_0': 0.09871596802152396}
Setting B - Betweenness Policy
{'infections_total': 574.7, 'infectious_current': 12.22, 'mortality_total': 186.92, 'r_0': 0.08790464731347082}
Setting C - Degree Policy
{'infections_total': 540.88, 'infectious_current': 11.8, 'mortality_total': 176.3, 'r_0': 0.08428470026705322}
Setting D - Mortality Policy
{'infections_total': 718.9, 'infectious_current': 17.46, 'mortality_total': 219.9, 'r_0': 0.0937050020047207}
```

G2:

```
--- G2 ---
Setting A - Random Policy
{'infections_total': 1223.1, 'infectious_current': 10.0, 'mortality_total': 456.86, 'r_0': 0.056240982383629456}
Setting B - Betweenness Policy
{'infections_total': 636.5, 'infectious_current': 5.64, 'mortality_total': 239.66, 'r_0': 0.057989249639249646}
Setting C - Degree Policy
{'infections_total': 622.22, 'infectious_current': 7.92, 'mortality_total': 229.62, 'r_0': 0.04694240481740481}
Setting D - Mortality Policy
{'infections_total': 1252.34, 'infectious_current': 11.1, 'mortality_total': 454.76, 'r_0': 0.05506526310806495}
```

c. Conclusion for Which policy is the best one in terms of:

- Total number of infections - **Degree Policy**
- The number of infected individuals after the specified epoch – **Betweenness Policy.**
- The total number of mortality cases - **Degree Policy.**

  By using the Degree Policy we get the lowest total number of infections and lowest total number of mortality, when we remove the nodes with the highest degrees we remove the highest number of edges from the network, and then the pathogen have less ways to move on the network. Using betweenness policy gives us similar results to the degree policy because most of the nodes with the highest degrees have high betweenness centrality.

  When we remove the nodes with the highest betweenness centrality we remove the ones that are in the highest number of shortest paths of all the other nodes, and then the epidemic can be shorter in time, as we cut the highest number of the total shortest paths of all the nodes. That's why we get the lowest number of infected individuals in the last epoch.

d. drawbacks of the vaccination policies suggested in this question:

When we use the mortality policy we get total infected number bigger than random policy and total mortality number similar to the random policy.

We get those result because probably the people with the highest mortality rate aren't connected to many nodes, and the mortality probability is not significant among the nodes in the given networks. I think when I will increase the number of vaccines I might see an improvement in the mortality policy.

When we used the random policy we can get nodes that are connected to many other nodes (high degrees).

we learned from the last question that if we vaccine nodes with higher degrees we can handle better the epidemic and stop her quicker with less nods that have died or got sick.

I think we can get the best results in the total mortality number if we combine the degree and mortality policy, as we will stop the epidemic and guard the people with high probability to die.

As for the networks we received I believe that using degree policy will give us the best results to handle the epidemic.

Betweenness policy will give us good results but not as good as the degree policy.

Random and mortality policies will give us bad results, as they don't handle the epidemic as good as the other policies. From those two we better use the random policy as the mortality policy will give us the worst results.