CSC 555 - PROGRAMMING ASSIGNMENT P2
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INTRODUCTION

The implementation has two classes to simulate the infection spread in a society. The first class models the society as a whole and the second class models each agent with certain functions like movement, transition from one infected state to another etc.

Model class:

Function descriptions:

- __init__(): The init function creates a Multi grid (where more than one agent can be in one cell). It creates the agents and places four of them in each grid which is called 'home' of the agent. Next it infects a random initial percentage of the agents to start off with.
- get_infections(): Counts the total number of agents who are infected and also the number of agents at each state of the infection transition.

Agent class:

Function descriptions:

- __init__(): Initializes all the class variables and sets every agent to uninfected.
- move(): Moves an agent from home to either grocery store or park with certain probabilities and moves an agent back home with a probability of 1. So every agent who goes out of the house comes back home.
- change_status(): Transitions the agent's infection from one state to another based on a probability.
- infect(): Checks if the agent's cell has any infected agents and changes the status accordingly. This function also takes care of quarantine people and maintaining social distancing. If an agent in the quarantine center is cured, the agent is moved back to the house. If an agent in the quarantine center is dead, then the agent is moved to another cell which does not take part in movement.

Visualization:

A separate method is written to run the model n number of times in order to reduce the effect of randomness in the result. This method calculates the average of all the runs and reports the value. A sample graph of the infection trend is also plotted in order to visualize and analyze patterns.

BASIC IMPLEMENTATION RESULTS

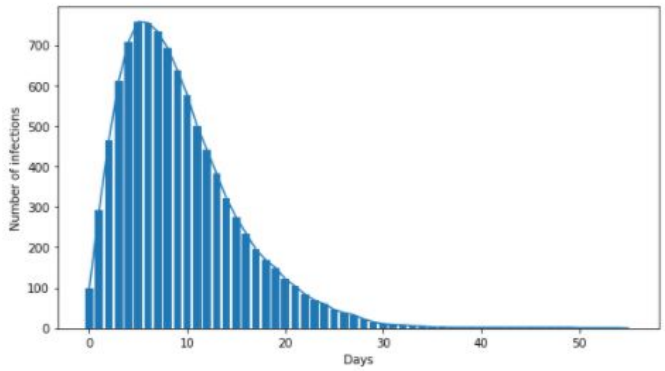
The models were run for initial infections of 10%, 25% and 50%. The following graphs were plotted.

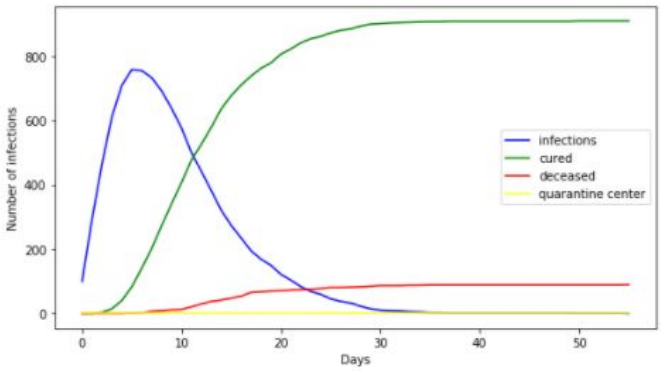
No quarantine or social distancing

10% initial infections:

```
With 10% initial infections:

Number of days: 46
Cured: 918
Dead: 80
Uninfected: 0
```



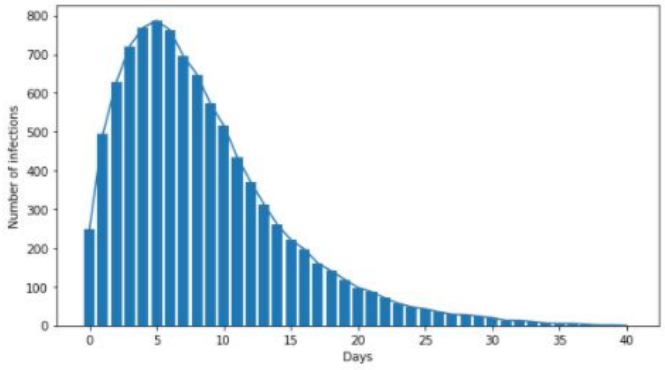


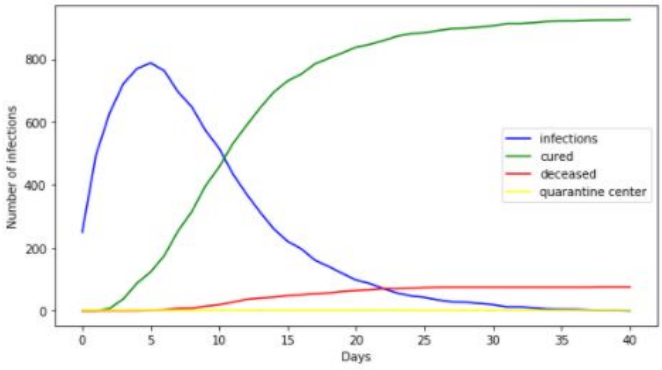
The peak is reached at the 5th or 6th day after initiation. The highest number of active cases in a day is somewhere between 700 and 800 tipping towards 800.

25% initial infections:

```
With 25% initial infections:

Number of days: 45
Cured: 919
Dead: 80
Uninfected: 0
```



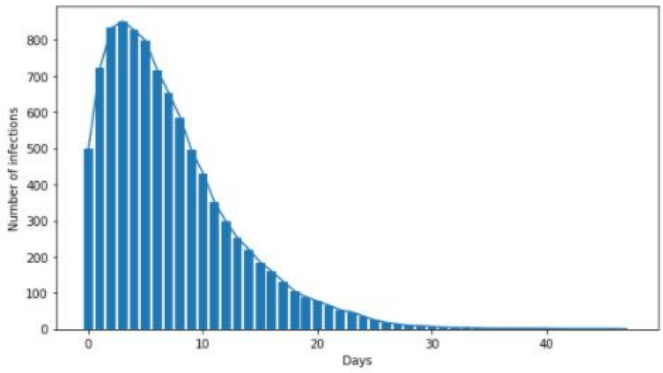


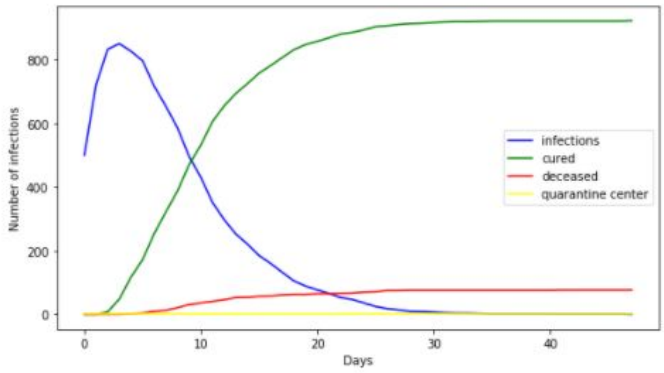
The peak is reached on the 5th day after initiation. The highest number of active cases in a day is somewhere between 700 and 800 tipping towards 800.

50% initial infections:

```
With 50% initial infections:

Number of days: 43
Cured: 919
Dead: 80
Uninfected: 0
```





The peak is reached on the 3rd day after initiation. The highest number of active cases in a day is somewhere between 800 and 900 almost at 850.

The values can be summarized as follows:

Initial (%)	Days (avg)	Cured (avg)	Deaths (avg)	Uninfected (avg)
10	46	918	80	0
25	45	919	80	0
50	43	919	80	0

It can be seen that everyone in the society gets affected and there is not much change in the number of cured agents, deaths and the number of days taken to stabilize between the three initial infection cases. The cure rate is about 92% and the death rate is about 8%.
In order to lessen the number of cases, quarantine centers are introduced.

QUARANTINE CENTER IMPLEMENTATION RESULTS

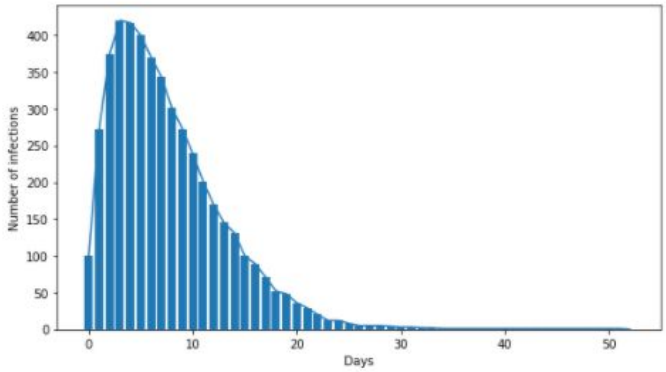
A single quarantine center was introduced with a capacity of 10% of the total population. The model was again run for 10%, 25% and 50% initial cases. The following results were obtained.

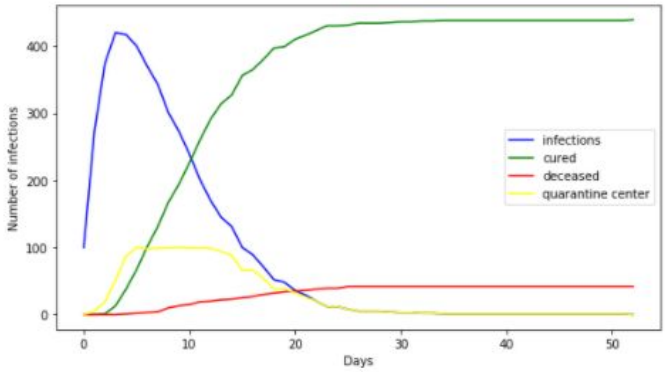
With quarantine center

10% initial infections

```
With 10% initial infections:

Number of days: 39
Cured: 460
Dead: 38
Uninfected: 500
```



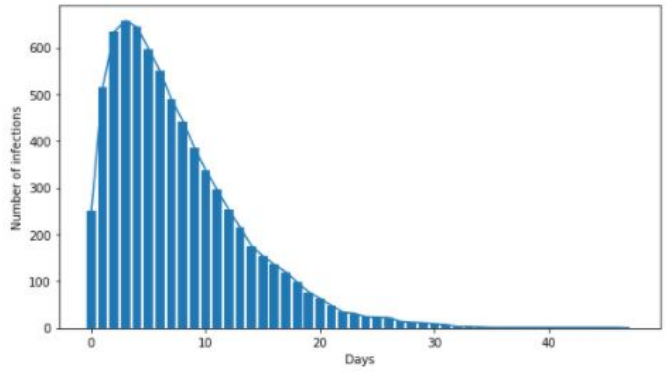


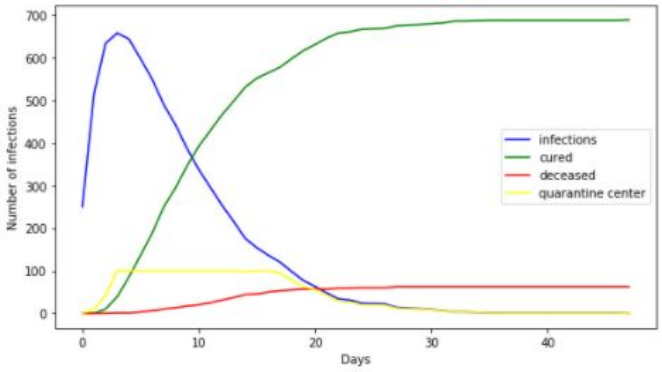
The peak is reached on the 3rd day after initiation. The highest number of active cases in a day is somewhere between 400 and 450 almost at 425.

25% initial infections

```
With 25% initial infections:

Number of days: 43
Cured: 665
Dead: 60
Uninfected: 273
```



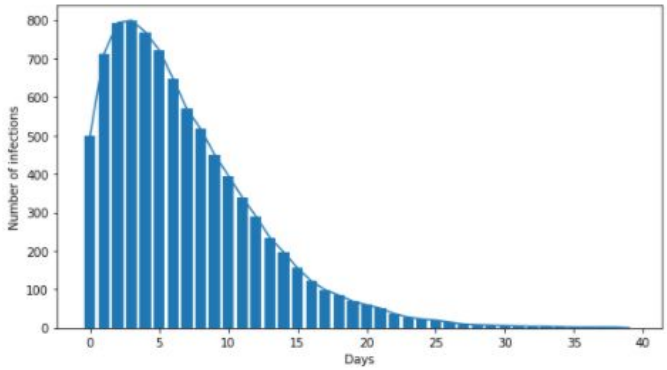


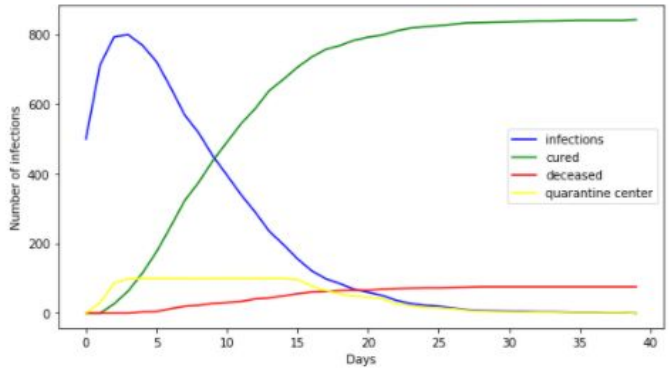
The peak is reached on the 3rd day after initiation. The highest number of active cases in a day is somewhere between 600 and 700 tipping towards 700.

50% initial infections

```
With 50% initial infections:

Number of days: 38
Cured: 845
Dead: 70
Uninfected: 84
```





The peak is reached on the 2nd or 3rd day after initiation. The highest number of active cases in a day is close to 800.

The values can be summarized as follows:

Initial (%)	Days (avg)	Cured (avg)	Deaths (avg)	Uninfected (avg)
10	39	460	38	500
25	43	665	60	273
50	38	845	70	84

It can be seen that the number of days taken to reach termination does not vary based on the initial infections. As and when the initial infections increase, the cure rate and the death rate remain the same. The cure rate is about 92% and the death rate is about 8%.

The quarantine center reaches its max capacity at the time step when the infection is at its peak and remains at max capacity until the time step when the total number of active cases reaches 100. The time stamp can be generalized as somewhere between 3 and 17.

SOCIAL DISTANCING + QUARANTINE CENTER IMPLEMENTATION RESULTS

To further reduce the infections, social distancing was proposed. The probability of getting infected reduces by 5 times the original probability when social distancing is in place. The following results were obtained.

With quarantine and social isolation

10% initial infections

```
With 10% initial infections:

Number of days: 51
Cured: 380
Dead: 34
Uninfected: 585
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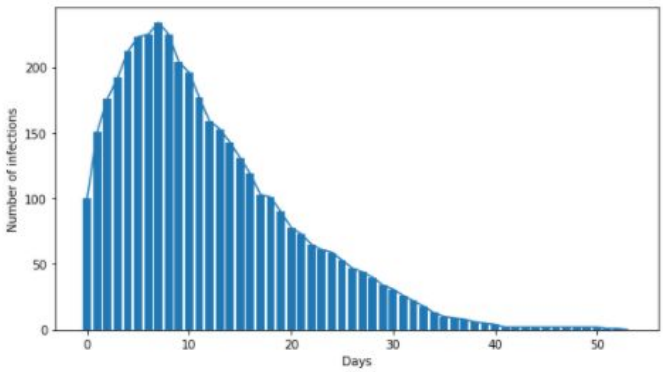
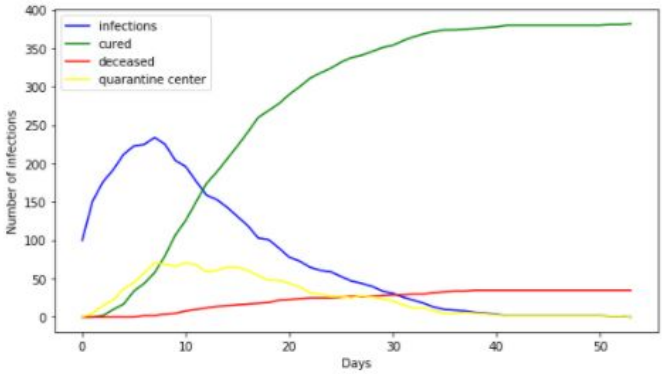


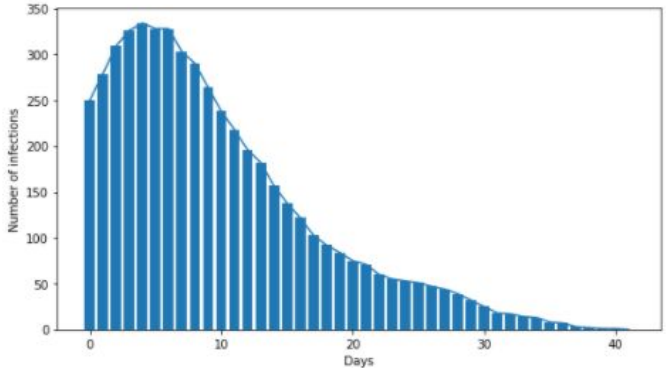


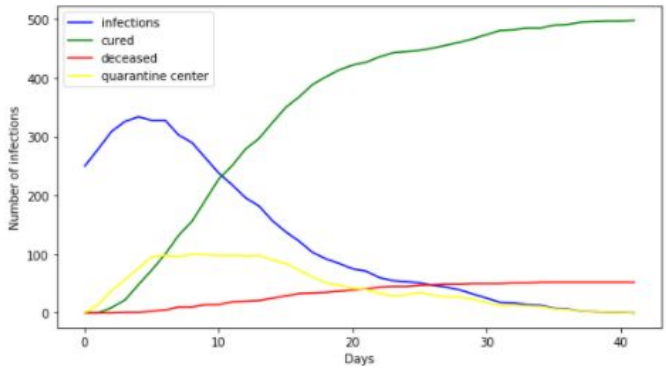
The peak is reached on the 8th day after initiation. The highest number of active cases in a day is close to 250.

25% initial infections

```
With 25% initial infections:

Number of days: 53
Cured: 532
Dead: 47
Uninfected: 420
```



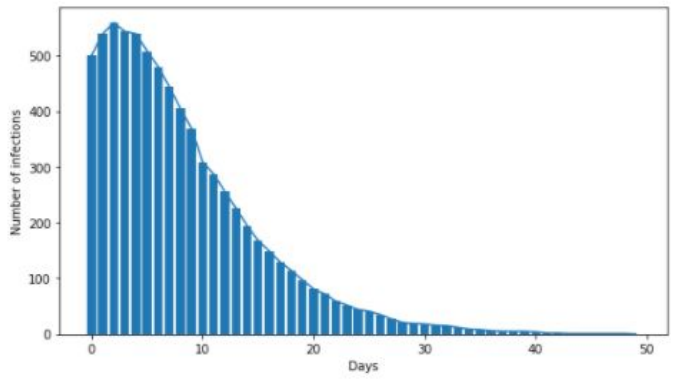


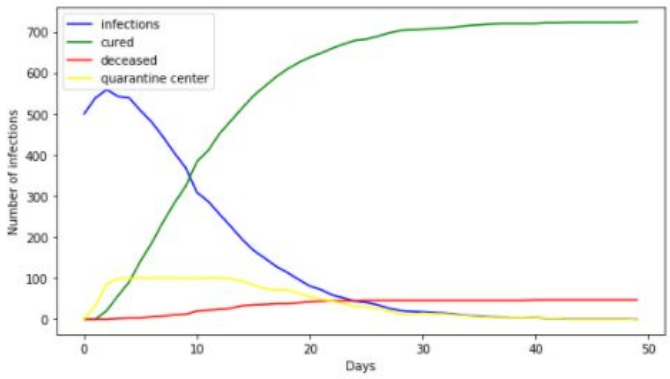
The peak is reached on the 5th day after initiation. The highest number of active cases in a day is close to 325.

50% initial infections

```
With 50% initial infections:

Number of days: 49
Cured: 723
Dead: 60
Uninfected: 216
```





The peak is reached on the 3rd day after initiation. The highest number of active cases in a day is close to 570.

The values can be summarized as follows:

Initial (%)	Days (avg)	Cured (avg)	Deaths (avg)	Uninfected (avg)
10	51	380	34	585
25	53	532	47	420
50	49	723	60	216

It can be seen that, again, the number of days for termination differ much for each initiation. The relationship between the initial state and the infection rate remains the same. When both the measures are taken, the infection rate reduces for each corresponding initial state when compared to the introduction of only the quarantine center.

Introducing social distancing improves the situation in that the number of people who are affected reduces when compared to the other methods. The death rate remains the same but since the number of total infections reduces, the total number of deaths also reduces.

CONCLUSION

One of the interesting findings I found was that the cure rate and the death rate are independent of all the factors. The cure rate was always 92% and the death rate was always 8%. This shows that the spread is faster but not quite fatal in all cases. The following table summarizes the infection percentages in all the three cases:

Initial (%)	Case 1 (%)	Case 2 (%)	Case 3 (%)
10	100	50	41.4
25	100	72.5	57.9
50	100	91.5	78.3

Case 1: No quarantine, no social distancing
Case 2: Only quarantine, no social distancing
Case 3: Both quarantine and social distancing

Considering the percentages for the three cases shown above, it can be seen that the number of infections reduces from case 1 to case 2 to case 3 for the corresponding initial states.

The impact of adding quarantine centers reduced the infections significantly but the number of days to stabilize was almost the same as case 1. Going beyond this to practice social distancing norms as well further reduced the infections but the difference from case 2 to case 3 was not very significant but there was certainly a reduction.

The influential factors in the spread of virus are:

- A large number of people are leaving the house.
- The limited capacity and the number of the quarantine centers.

To fix these issues, we can do the following:

- Reduce the probability of a person going out of the house.
- Increase the number of quarantine centers and increase capacity to accommodate more infected people to reduce the rate of spread and prevent the infected people from moving around.
- Since there is no way to know if the person is affected when in asymptomatic state, we need to find ways to detect this by performing certain actions which will give a sign if the person is infected or not.