IE 206 Scientific Computing for Industrial Engineering

Project 1

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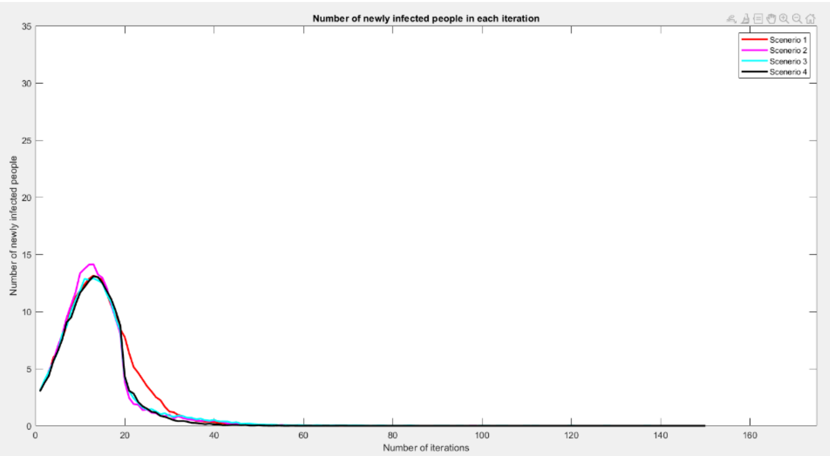
We assumed that the vaccinated people could have their second vaccine at least 3 days after their first one. This means that they can be vaccinated not only after exacting 3 days, but also in the following days in Scenario 4. It also means that the probability of get infected increased to 0.5 which is given as p in guideline between the first and the second vaccinate.

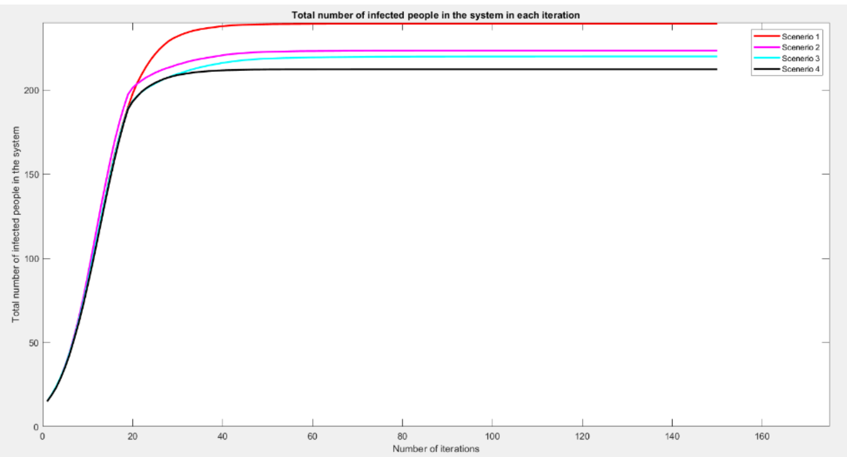
Part 1

Part 1.1



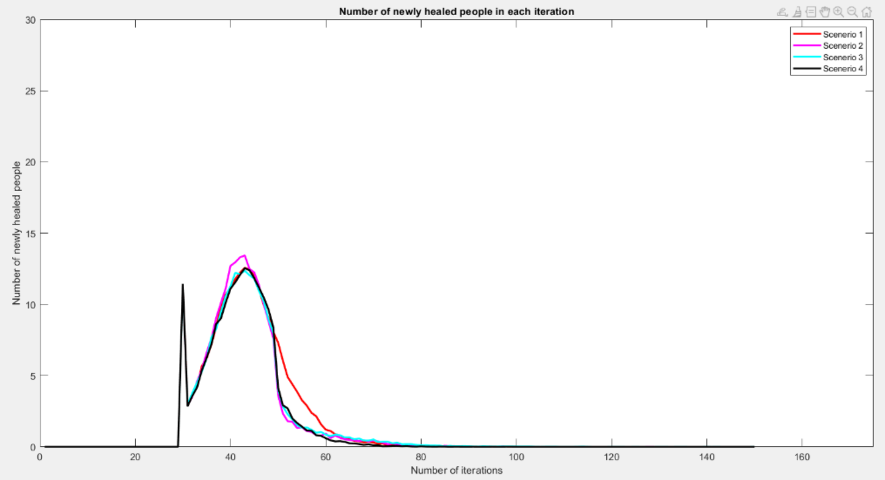
It is known that there were 12 infected people before the iterations started, but since the graph above begins from day 1, that peak point cannot be seen. In each scenario, the number of newly infected people reached the peak point before the 20th. However, Scenario 2 has a significantly higher peak point than other scenarios since there was no applied policy before day 20. When the decreasing rate declined in Scenario 2, Scenario 3, and Scenario 4 after day 20 since vaccination started on the 20th day, opposites these scenarios, it decreased at the same rate in Scenario 1. Finally, the number of infected people approached 0 at around the 50th day.

Part 1.2



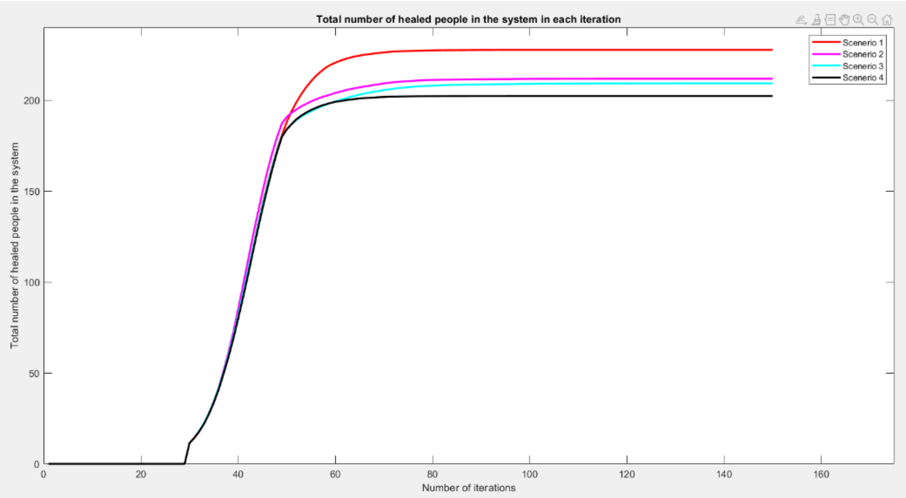
In all scenarios, the increase in the total number of infected people was quite similar before the 20th day. However, after the 20th-day increasing rate, the total number of infected people declined significantly in Scenario 2, Scenario3, and Scenario 4 because vaccination started on that date. Moreover, the increasing rate decreased after the 23rd day in Scenario 4 because the second vaccination policy started on that day. Moreover, the upper limit of the total number of infected people was the highest in Scenario 1 and the lowest in Scenario 4. It shows that the isolation policy by itself is not efficient in decreasing the total number of infected people, but when both the vaccination policy with double dose and the isolation policy are applied together, the minimum number of people are infected. In addition to that, the increasing rate of the total number of infected people decreased slightly in Scenario 1 after the 30th day since people were getting to heal after 30 days by 95% chance.

Part 1.3



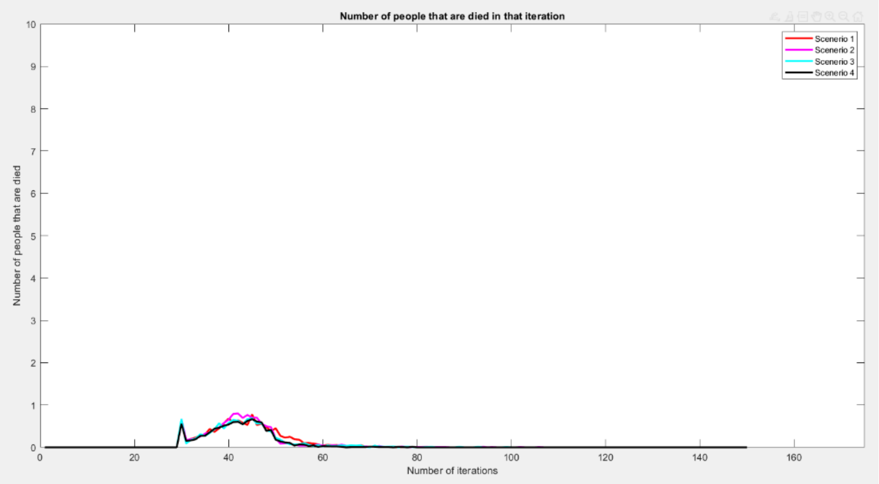
It is observed a peak on the 30th day in all scenarios as 12 people were assumed to be infected initially, and they healed earliest on the 30th day. Since infected people have a 95% chance of recovering, the graph of newly healed people is quite similar to the 30-day shift graph of newly infected people in all scenarios. However, these graphs are not exactly the same as the probability of not healing is 5%. The same comments on the graph of newly number of infected people can also be made for this graph for all scenarios, only after 30 days.

Part 1.4



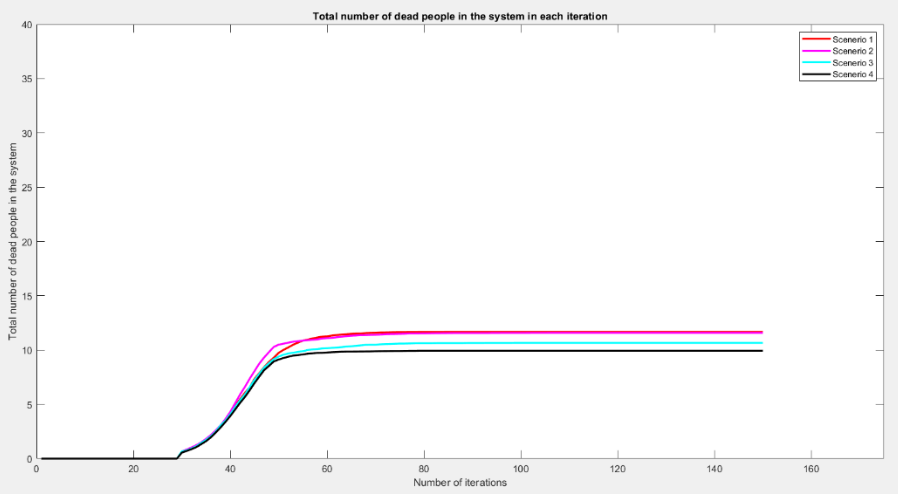
Since infected people healed by 95% chance in all scenarios, the total number of healed people in the system in each iteration started to increase after the 30th day until all the population healed or died. The upper limit of healed people is highest in Scenario 1 because there were more infected people in Scenario 1. Likewise, the upper limit of healed people is lowest in Scenario 4 because there were fewest infected people in Scenario 4. Other comments about this graph are the same as the graph of the total number of infected people in all scenarios, only after 30 days.

Part 1.5



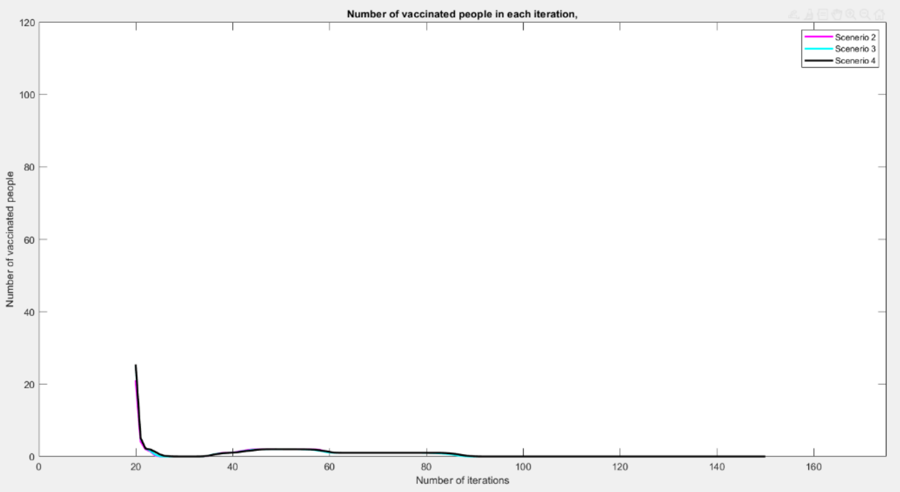
People started to die on the 30th day because people can heal at 95% probability, which means that they can die at 5% probability. Furthermore, while the number of infected people is increasing, so does the number of people who die. It is observed that the number of dead people in Scenario 1 decreased after its peak point with the lowest rate, while Scenario 4 decreased after its peak point with the highest rate. Also, the decrease rate of the number of dead people inclined after the 50th day since vaccination started in Scenario 2 and Scenario 3.

Part 1.6



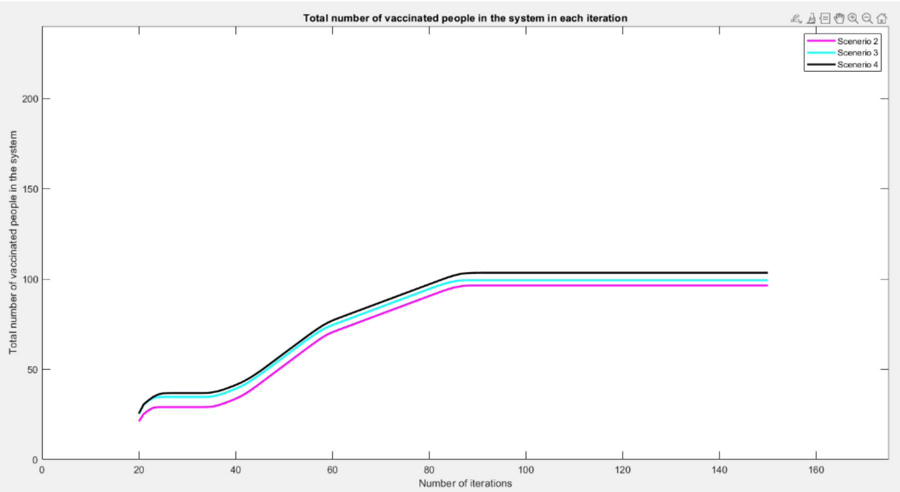
People started to die on the 30th day because they can heal at 95% probability; however, it means that they can die at 5% probability. Furthermore, while the number of infected people increases, so does the number of people who die. The upper limit of the total number of dead people in Scenario 4 is found as the least since isolation and double vaccination policies were applied together.

Part 1.7



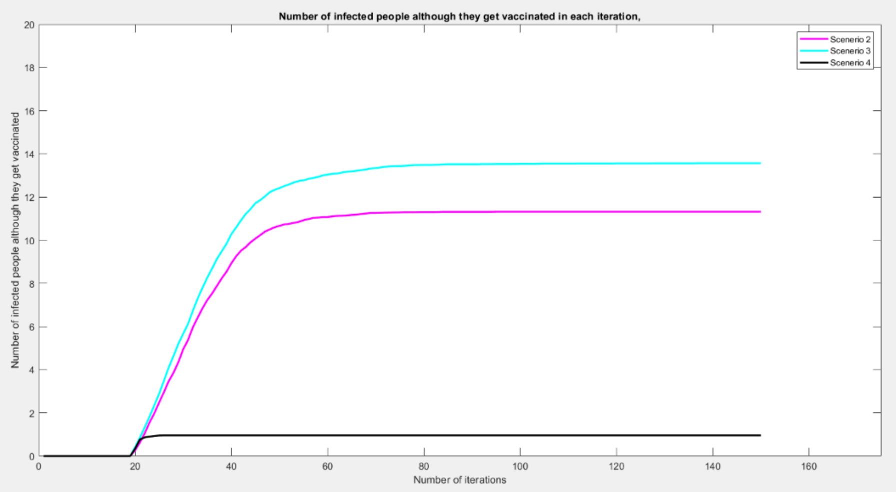
The beginning of the graph is observed on the 20th day. In the beginning, the number of vaccinated people was higher in Scenario 3 and 4 than in Scenario 2. Because the isolation policy was applied, there were more healthy people in Scenarios 3 and 4. After that, the same number of vaccinated people in each iteration was observed on average for all scenarios except 1. In all scenarios except 1, the number of vaccinated people was similar to each other, and they were approached 0 around the 130th day.

Part 1.8



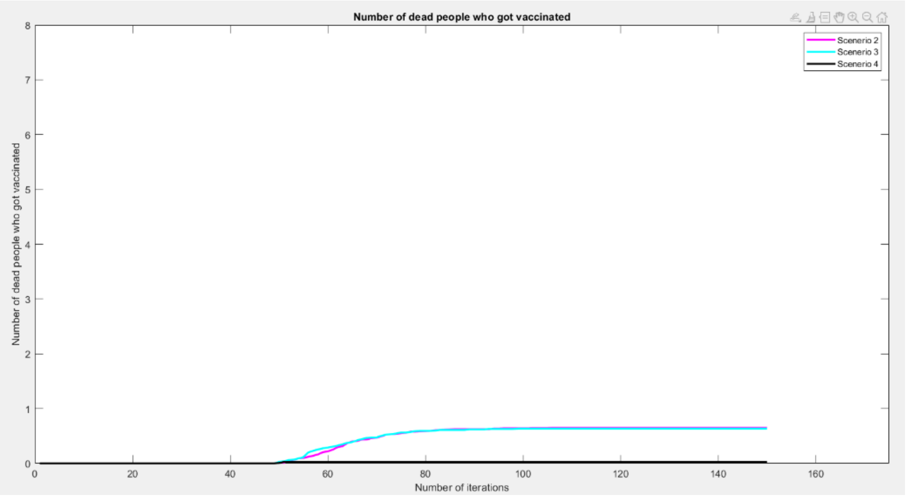
In which scenario the number of healthy people is higher than in other scenarios, the number of people vaccinated is higher because vaccination applied with the ratio of 1/(tv-19) of healthy people subject to tv = 20,21,22… Hence, the total number of vaccinated people in Scenario 4 is the highest, in Scenario 2 is the lowest during the 130 days.

Part 1.9



Since the total number of vaccinated people in Scenario 3 is higher than in other scenarios, the number of infected people, although they get vaccinated, is the highest in Scenario 3. In Scenario 2 total number of infected people, although they get vaccinated, is a little less than in Scenario 3 but higher than in Scenario 4. The probability of vaccinated people getting infected is relatively low in Scenario 4 because people have a 0.8 possibility of getting their second dose of vaccines, and the rate of infection decreases to 0 after they get the second dose of vaccines. As shown in the above figure, one person is infected although he got vaccinated.

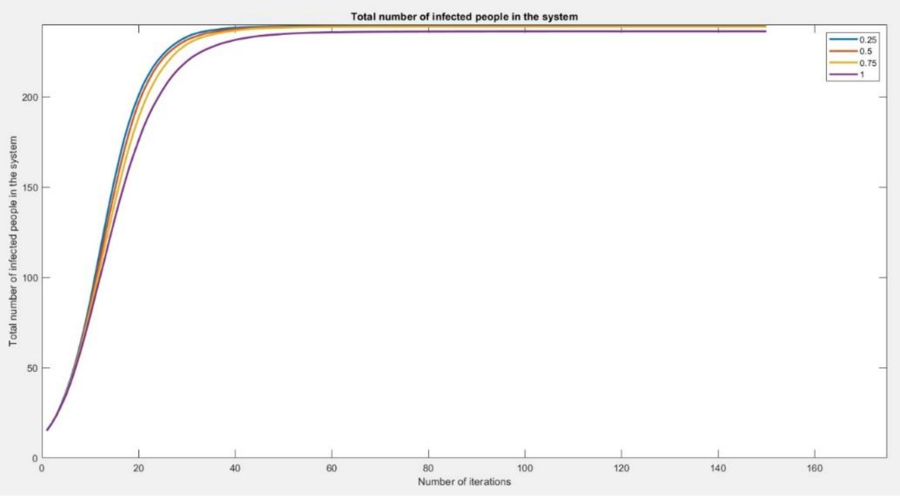
Part 1.10



There were some people who died in Scenario 2 and Scenario 3. However, there is nobody who died, although he gets vaccinated in Scenario 4. It shows that when isolation and double-vaccination policies were applied together, the number of people who got vaccinated dropped to 0.

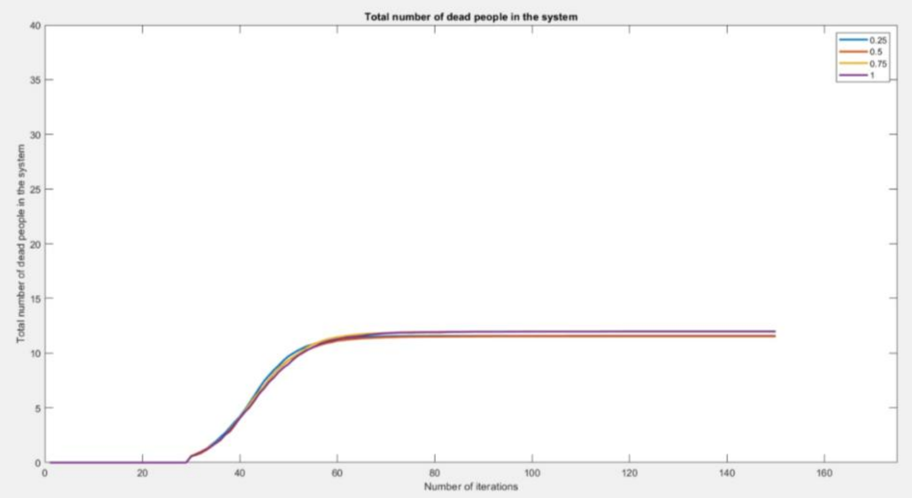
Part 2

Part 2.1.1



In Scenario 1, as the isolation rate increases, the increase rate of the total number of infected people and the upper level of the total number of infected people decrease insignificantly. Only isolation could delay the time it takes for people to get infected; however, it does not significantly affect the total number of infected people. The change in isolation rates did not create a massive change in the total number of infected people. Hence, decision-makers should not only apply isolation policy; they can apply it to vaccination policy.

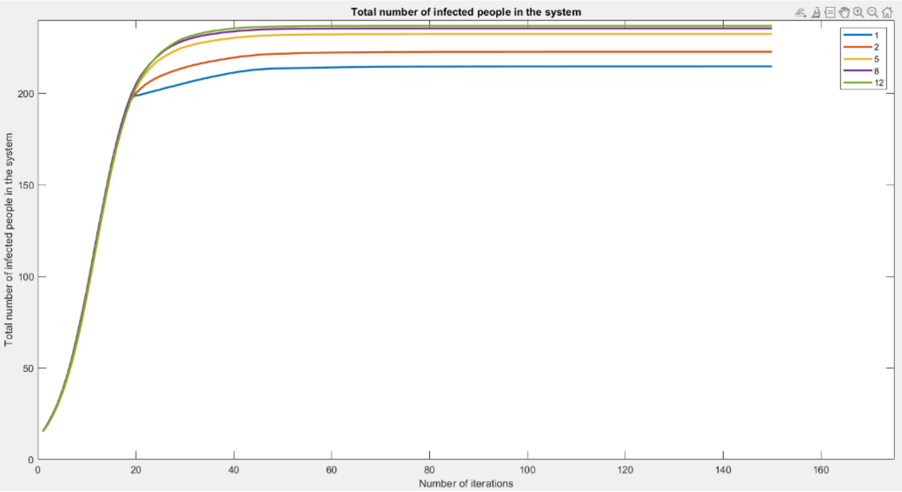
Part 2.1.2



On the other hand, since the isolation only delays the time of infection and has no meaningful effect on the total number of infected people, no remarkable change is observed in the total number of dead people in Scenario 1. The same comments in the total number of the infected graph can be said for this graph, too. Hence, decision-makers can apply both vaccination and isolation policy since isolation policy by itself is insufficient.

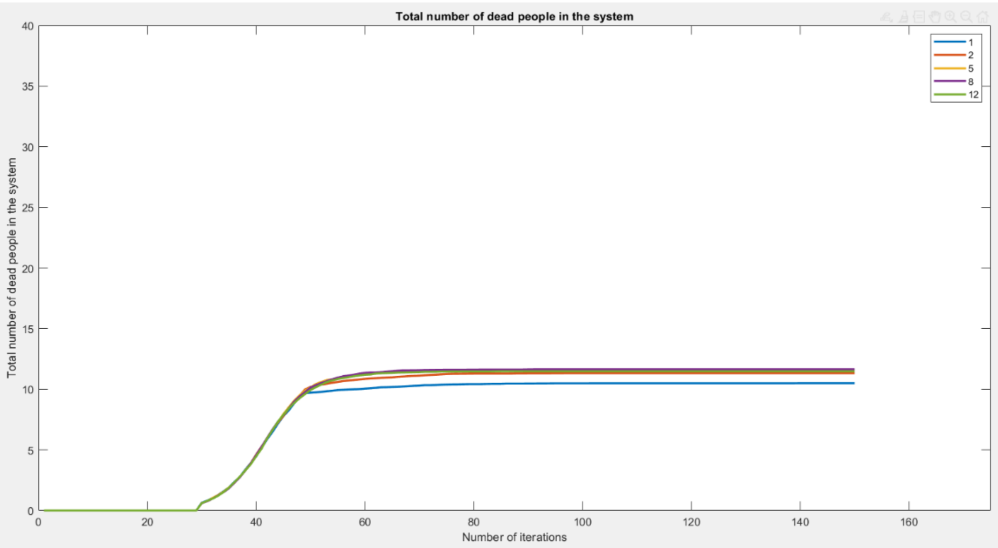
Part 2.2.1

The legend represents the coefficients in rate of vaccination of healthy people. $\frac{1}{2(tv-19)}$ tv= 20,21,22…



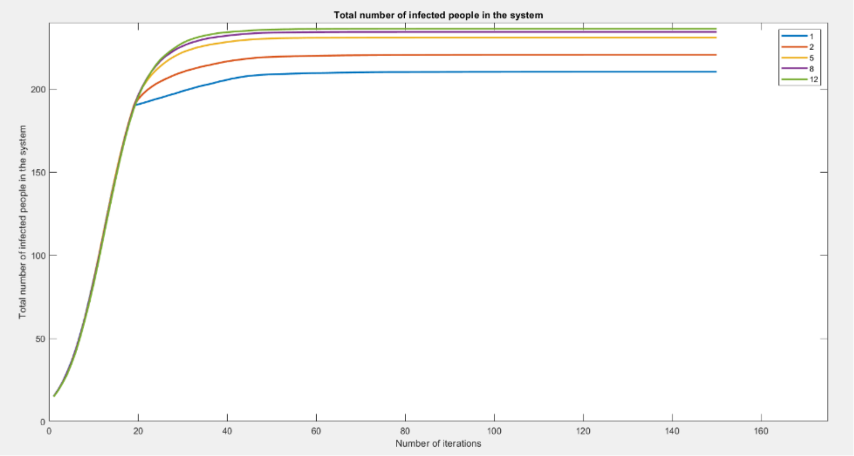
When the vaccination rate was 1, the total number of infected people was the lowest, and when the vaccination rate was 1/12, the total number of infected people was the highest. It shows that as the vaccination rate decrease, the total number of infected people increases, and vaccination works even by itself. Even when the vaccination rate is 1, we get the best result, and it is not a suitable solution in real life. Hence, decision-makers should enforce vaccination policy as high as possible in the society to decline the infection.

Part 2.2.2



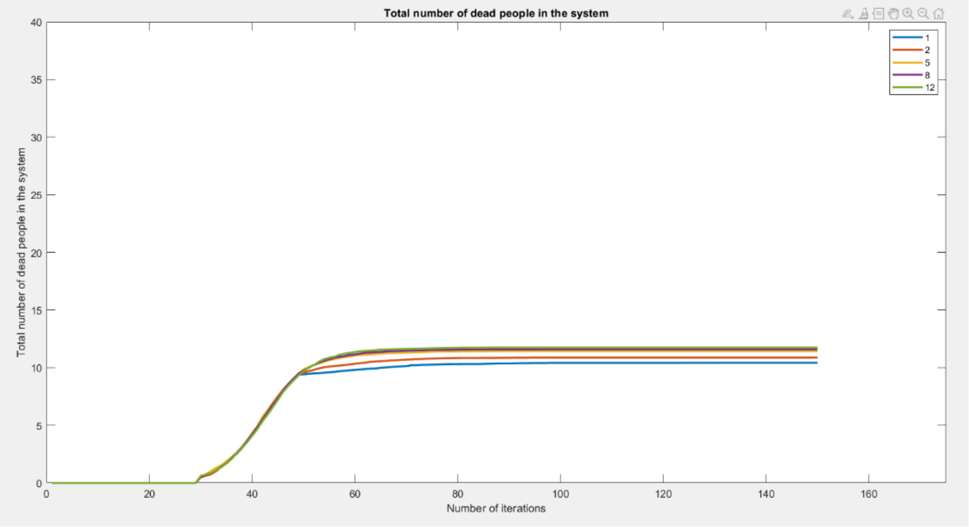
As the vaccination rate increase, the total number of dead people decrease. However, as the vaccination rate decrease, the total number of dead people does not change significantly. Hence, the government can enforce vaccination policy even at slightly lower rates with any other policies such as isolation to decline the total number of death.

Part 2.3.1



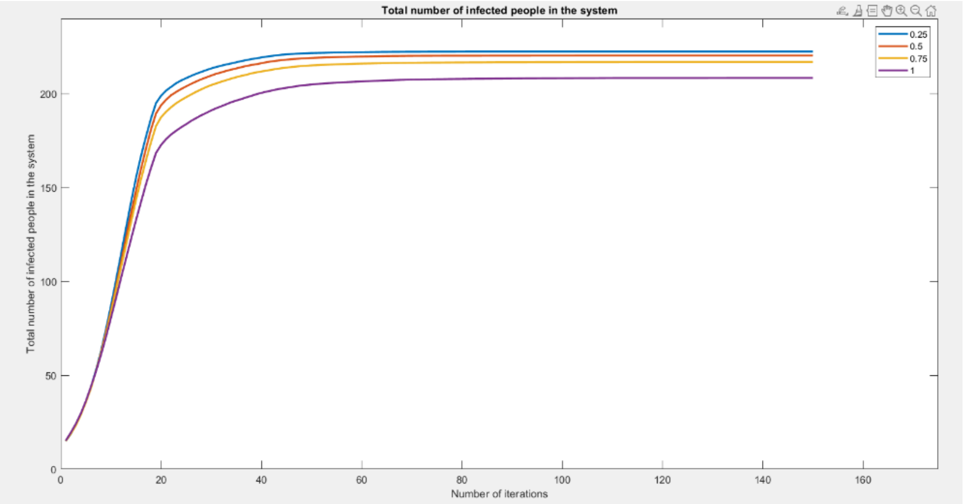
Because scenario 3 contains both isolation and vaccination, the number of people who are not infected is more in the 20th iteration than in scenarios 1 and 2, resulting in a higher number of people vaccinated in the first vaccinations. If the vaccination rate is reduced after the 20th iteration, the disease is spread quicker, and too many individuals become infected (approaching the results of Scenario 1). Because the first 40-50 iterations are critical in the spread of the disease, a reduction in the vaccination rate impacts the overall number of persons who get infected in later iterations. 5,8 and 12 vaccination rate divisors are considerably low, and their results is not acceptable.

Part 2.3.2.



Since death rates also depend on infected people, total deaths increase at lower vaccination rates. When the vaccination rate is 1 (in condition divisor of vaccination rate is 1), everyone healthy has been vaccinated. Although this vaccination rate is effective, it will be impossible to handle real-world conditions. As a result, selecting a vaccination divisor between 2 and 1 will result in a more logical and applicable vaccination rate.

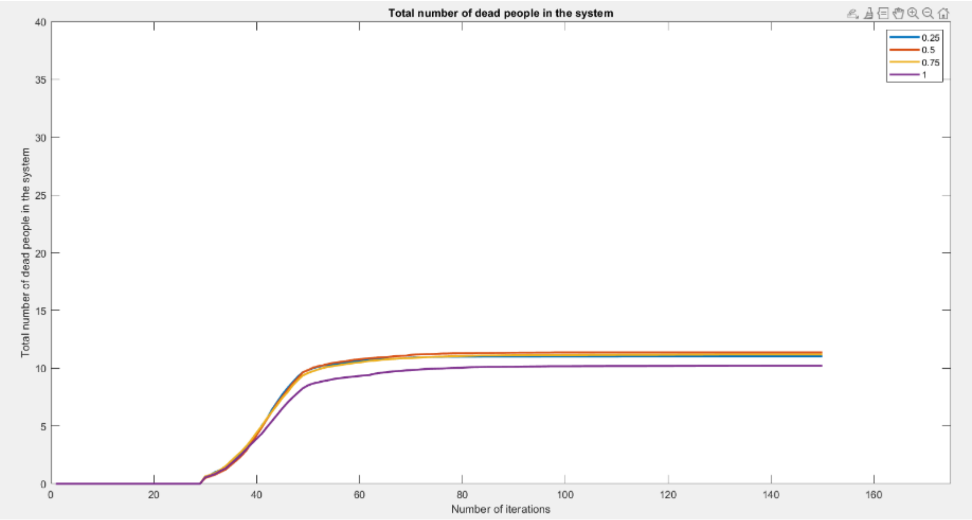
Part 2.4.1



Because isolation slows down the spread of infection but does not stop it, the total number of patients reduces as the isolation probability increases until the 20th iteration. Since they can be vaccinated in Scenario 3, the more people who make it to the 20th iteration without getting infected, the better their chances of not getting infected until the disease is eradicated. Because most of the infected people have become healed or died after 50 iterations. So, the average number of total infected people becomes low. The isolation chance of 0.25 leads nearly everyone to become infected. There is a noticeable difference between the probability of 0.75 and 1 regarding the number of people infected. To sum up, the best results were obtained in complete isolation.

Even if the differences between 0.75, 0.50, and 0.25 are minor, the difference between 0.75 and 1 is significant. There are minor differences between them as the disease rapidly spreads before vaccination starts for other probabilities. The total number of persons with the disease must be low for the death rate to decrease.

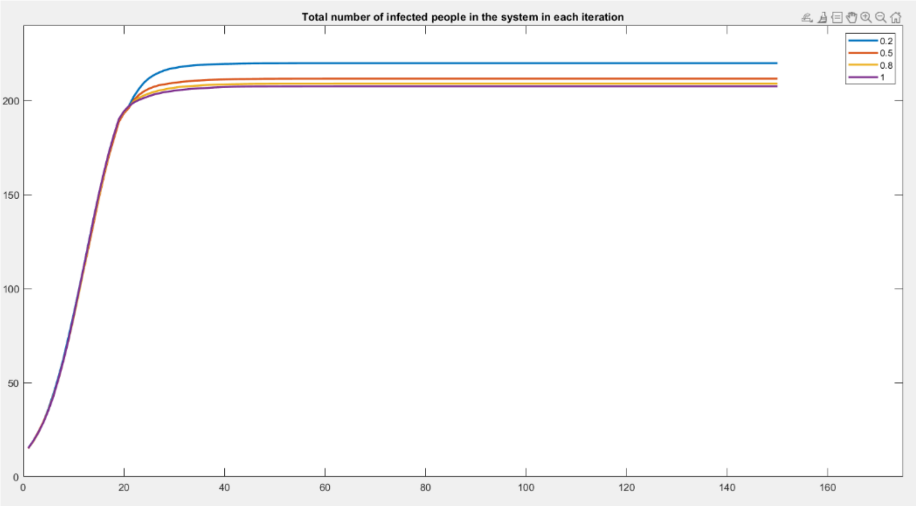
Part 2.4.2



Because there is no significant difference in the total number of infected people between the possibilities of 0.25, 0.5, or 0.75, there is no noticeable change in the mortality rates. Despite taking the average of numerous simulations, the overall number of fatalities does not vary because of the randomness; the difference is negligible. However, mortality rates are dramatically lowered when all infected persons are isolated (total isolation), and with vaccination, a considerable reduction in the overall number of patients is accomplished.

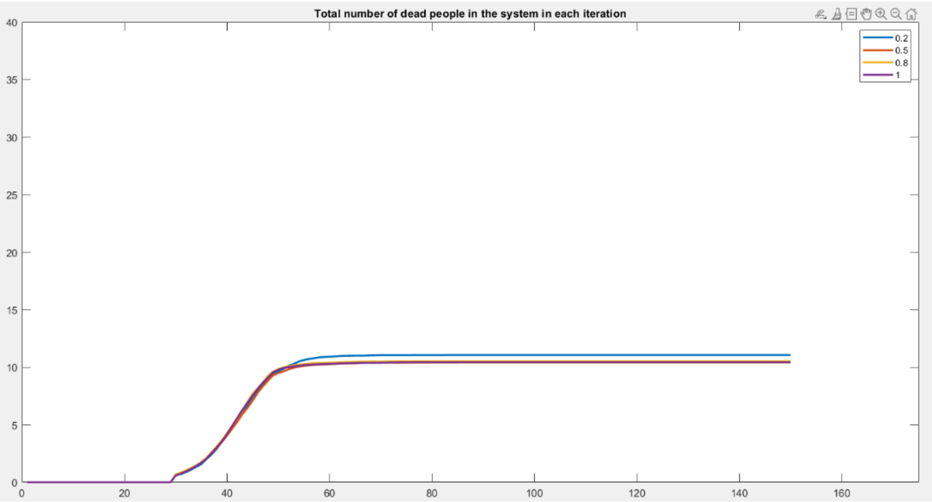
Part 2.5.1.

We assumed that the change of the value given as w= 0.8 while finding the impact of different rate of second vaccination on total number of infected and dead people in the system through the iterations in Part 2.5.1. and Part 2.5.2.



Since there is both isolation and the second vaccine in scenario 4, the death rates are low. As the rate of getting the second vaccine increases, both the deaths and the total number of sick people decrease. As seen in the graph, the total number of infected people is high when the probability of getting the second vaccine is 0.2. We can observe that the total number of patients decreases when the chance of the second vaccine is increased to 0.5. There is no significant difference between 0.5 and 0.8 and 1 because we accept that there will be a vaccine in every iteration after the 3rd iteration; the other possibilities other than the 0.2 probability do not make a big difference.

Part 2.5.2.



When we look at the total number of deaths, we can observe that the difference in their probabilities is not noticeable. Again, there is no significant difference between 0.5 and 1 probability. Therefore, keeping the second vaccination rate around 0.5 can prevent the waste of resources.

Conclusion

As a result, the most logical and applicable scenario is scenario 4. The reason for choosing scenario 4 is that it is more efficient than other scenarios in terms of total deaths. The impact of isolation and vaccination is much more significant than applied only one of them. Vaccination can be started sooner, with isolation. In that case, the total number of infected people and deaths may dramatically decrease. Because until the 20th iteration, 75% of the population has become infected, starting vaccination early can prevent the spread of the disease to a high degree.