Covid – 19: Virus transmission simulation with SIER model

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**Introduction**

We designed the virus transmission simulation based on the SIER (susceptible-exposed-infected-removed). The model depends on various parameters that will characterize the virus, population, and residence. As these parameters are expected to vary significantly, our project can be adjusted with the dynamic population, virus, and residence dependent parameters.

**Aim of the project**

We are deterministic to find the persistence of the pandemic considering control measures. This study of incorporating the SEIR model to covid – 19 dynamics with the pathogen and resident parameters helps to get the reproduction rate (R – factor) and Dispersion rate (K – factor). We follow the stochastic approach generating random data to find these factors.

**Project Details**

We model the population interacting into four categories as stated below:

Susceptible (S): Susceptible individuals are those who were never been infected with the virus and have no immunity against COVID-19. Susceptible individuals become exposed once they are infected with the disease.

Exposed (E): Those who have been infected but are not yet infectious themselves.

Infectious (I): Individuals present clinical symptoms and are infectious and can spread the virus to those who come into close contact. Usually, they are reported as confirmed cases.

Removed (R): Removed individuals include deceased patients and recovered ones who are immune to future infection from COVID-19.

Population P = S + E + I + R

We considered the below properties for a person which are dynamic and dependent to the set of population.

Activity Rate: The rate of people goes out every day.

Activity Radius: This is the radius of the resident’s activities.

The properties of the pathogen can be dynamic which includes in the **Virus** class:

Infectious Radius: The radius within which the person can get infected.

Infectious Rate: The probability at which the disease can be transmitted between susceptible and infectious person.

Removal Rate: This is the mortality rate for an infected person.

Recovery Rate: Recovery rate is the rate at which the infected person can recover.

Incidence Rate: This is the rate at which the exposed person becomes infective.

Infectious Period: The average number of days a person is infectious.

We considered the effectiveness of measures in **Measure** class as a significant property which vary and determine the persistence and effect of the epidemic.

Virus Testing: The number of tests performed per day.

Vaccine: Production and usage of number of vaccines per day.

Mask use rate and Mask effectiveness: These parameters define the usage rate and its effectiveness of the mask.

Quarantine rate: The probability at which each infected person obeys the quarantine rule.

We defined the reproduction rate R - factor, as the ratio of the exposed residents to the infected residents, R = E/I.

We calculate the K – factor by summing up the number of exposed and infected residents and check with the infection rate and take the ratio of the total residents who spread with the sum.

**Implementation and design**

The project has multiple functions defined to calculate if the person is infected, spread of virus, measure of vaccine and testing and calculate the R and K factor.

Get the parameters of Virus, Measure and Residence from the properties file. We then generate the residents and generate the initially infected persons in the constructor of residence. We define the location and initial status of the person.

*Spread Virus:* We consider all the residents and for two persons inside the residents, if either of the two person is contagious, we consider the distance between two person and if the distance is less than the Infectious radius then we try to infect the other.

If (p1 is contagious || p2 is contagious)

If (distance < infectious radius)

Infect (p1 or p2)

*Infect:* We consider the stochastic random generation process here. We take the value and compare with the mask usage rate and mask effectiveness rate. If both the random generated values less than the mask measure parameters and infectious rate, we consider the person as infected.

If (random < mask usage || random < mask effective) return

If (random < infectious rate) set person as infected.

*Update resident status:* We update the status of the residents by considering the person status.

We categorize the count of each person and update the susceptible, exposed, infected and removed if the person is recovered and if random generated value greater than the recovery rate then we update the count of the dead residents.

*CalculateRK:* We sum the exposed and infected count for each day and the reproduction rate, R – factor is calculated as the ration of the exposed to the infected residents.

We calculate the dispersion rate, K – factor as the ratio of the top spreaders (count of people infected by) to the sum of exposed and infected.

R = dE/dI.

K = top spreaders/E+I

*Apply Measure:* We then apply measures like vaccine and virus testing. We have the number of vaccines produced per day and keep track of the vaccines given. If person is susceptible then we give the vaccine and set the status of the person as removed and decrement the vaccine count.

If (person susceptible) set person status removed

We have the number testing kits and when we test the person, we consider the person who is exposed and infected and if the random generated value is less than the quarantine rate from measure parameter we set the status of the person as removed.

If ((person is exposed or infected) and (random < quarantine rate))

Set person status removed.

*Export CSV:* Finally, if the count of exposed and infected is 0, we pump the results and logs to the csv file. We publish the number of days it take for humans to fight over the persistence of the covid – 19 virus transmission.

**Simulation Stats**: The simulation of the Covid virus transmission is popped with an interesting GUI which updates stats of the simulation for each day. (Video recording of the simulation is uploaded).

A**nalysis and data visualization:**

We take this data and do the statistical analysis to implement visual charts.

