FH University of Applied Sciences TECHNIKUM WIEN

REPORT

Degree Program Medical Engineering & eHealth

Course Bioinformatics

Bioinformatics: Assignment a5

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1 Research, disease selection, simulation preparations and intervention

Due to an ongoing pandemic for the last more than two years, the selection of an infectious disease for the implementation of an SIR model was straight forward: I decided to tackle COVID-19 infections in Austria during the previous wave. Therefore, the 1st of February 2022 was selected as start of the simulation.

As a reliable data source, the Austrian ministry of health page, regarding COVID-19 reports, providing open data (https://info.gesundheitsministerium.at/opendata#COVID19_vaccination_doses_timeline) [1] and the "AGES Dashboard COVID19" (https://covid19-dashboard.ages.at/) [2], also providing data tables, were taken into account. Regarding the timeframe of the simulation, 100 days were defined as primary simulation duration. Within the table downloaded from [2], a column indicating the number of citizens of Austria could be used to define the overall population N. On February 1st, 8,932,664 people were registered in Austria and thus indicating the initial population N of the simulation. Additionally, this table provided insight into the infected and recovered people on the day of February 1st. Thus, I_0 (number of initially infected people) was set to 380,851 and R_0 (number of initially recovered people) was set to 1,552,182 people. Deducting those two compartments from the overall population resulted in 6,999,631 susceptible people.

In order to identify the recovery rate for the SIR model, literature research was performed. Espinose et al. [3] therefore indicated a mean recovery duration of 17 days, which is also based on further literature [4], [5]. The parameter γ was therefore assumed as 1/17, since it represents a recovery rate in 1/days. In order to determine the contact rate β in terms of the COVID-19 pandemic, Cooper et al. [6] was taken as reference. Within their work they state a contact rate of 0.18 for Italy. For this simulation it was assumed, that the contact rate for Austria might be approximately the same as for Italy.

In addition to the basic SIR model including the contact rate β and the recovery rate γ and to include vaccinations and general birth and death rates, the model initial SIR model was extended according to Kopfová et al. [7]. Therefore, the vaccination rate ν as well as the birth/mortality rate μ were added to the existing SIR model. The differential equations used for the simulations can be seen in Equation 1.

For the initial vaccination rate, the number of administered 3rd vaccination doses on February 1st were divided by the population N, which resulted in 0.26%. For the birth/mortality rate μ Bjørnstad et al. was taken as a reference, where they assume this ratio as 1/76 years, which in the context of this simulation resulted in a ratio of $\mu = 3.6 \cdot 10^{-5}$ 1/days.

Equation 1: Summary of equations for SIR model.

$$\dot{S} = -\frac{\beta SI}{N} - \upsilon S - \mu S + \mu N,$$
$$\dot{I} = \frac{\beta SI}{N} - \gamma I - \mu I,$$
$$\dot{R} = \gamma I + \upsilon S - \mu R,$$

The hypothetical intervention introduced within this simulation was an increase in vaccinations per day to 1% of the population which was also assumed as reasonable by Law et al. [8]. This may have been achieved using bonus system or a compulsory vaccination regulation.

2 Results and discussion

The simulation was firstly performed without intervention (seeFigure 1, left plot) and subsequently with an increased vaccination rate of 1%, which can be seen in Figure 1, right plot. Within the first simulation, the infected compartment peaked in 1,711,448 people after approximately 35 days. Including the increased vaccination rate, the most people were infected after about 30 days with a total of 1,299,149. Comparing those numbers, the increase in vaccination rate resulted in a decrease in maximum infections of 412,299 people and a flattening of the curve.

The actual COVID-19 cases in Austria peaked at about mid of March, which would correspond to about 40 days after February 1st, with 1.027 million of infected people. Comparing the results of the simulation with this maximum, the simulations show a slight overestimation which may occur due to a too a contact rate assumed as equal to Italy, which might be lower in Austria.

Concluding it can be stated that the SIR model, including vaccination and birth/mortality rate can be used to model and predict the spread of infectious diseases, thus also in case of COVID-19.

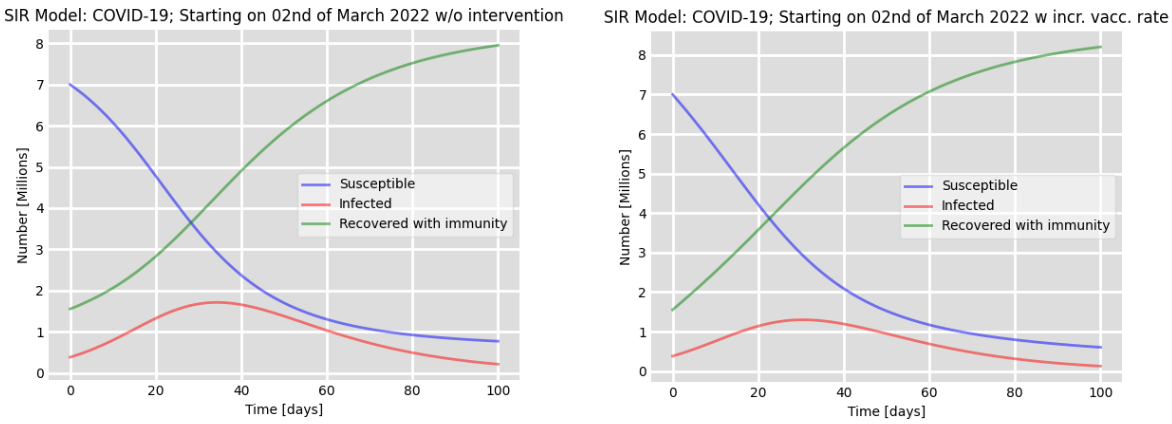

Figure 1: SIR-model simulations without intervention (left plot) and with intervention, implicating increase in vaccination rate (right plot).

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