Modelling With Differential Equation

Ordinary Differential Equation (GMAT2308 - A)

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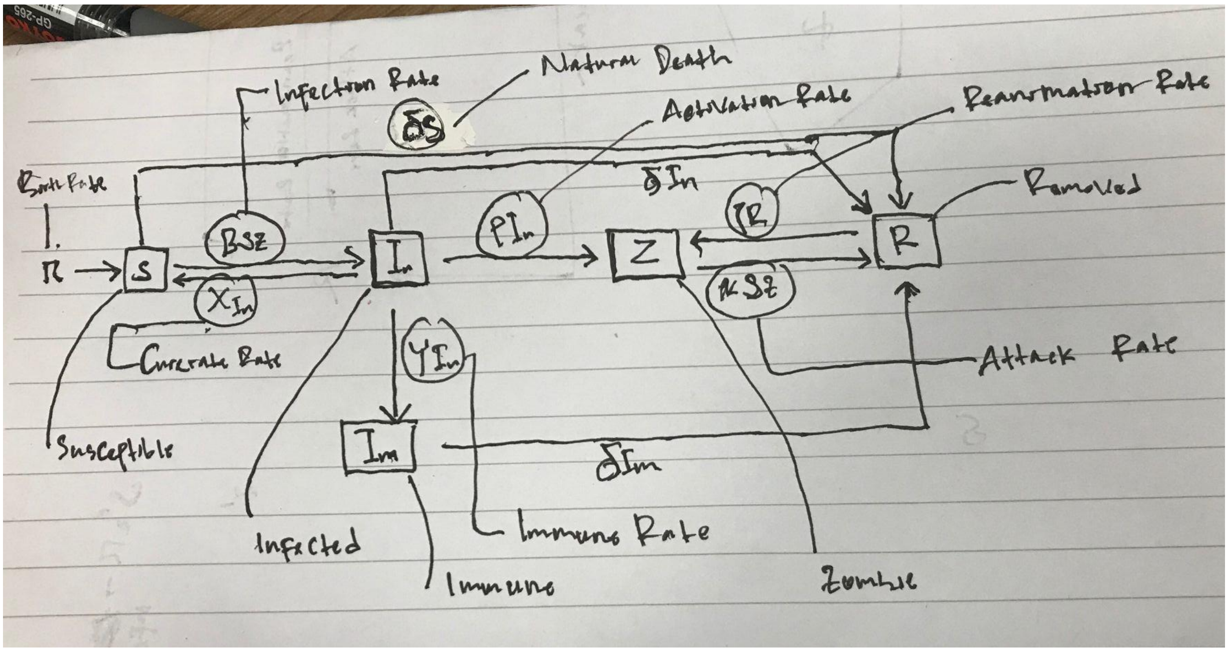
1.Improved SZR Model



$$S' = \Pi - \beta SZ - \delta S$$
$$I_n' = \beta SZ - \rho I_n - \delta I_n - \gamma I_m$$
$$Z' = \rho I_n + \zeta R - \alpha SZ$$
$$I_m' = \gamma I_m - \delta I_m$$
$$R' = \delta S + \delta I + \delta I_m + \alpha SZ - \zeta R$$

S is susceptible. **Im** is immune, where some of the susceptible may have genes that make them immune to the virus, but still capable to die due to natural causes like susceptible. Natural death itself includes the attack from the zombies, as the zombies may kill the host before turning them into infected, and within the case of susceptibles can be reanimated to a zombie, whereas the immune will not be reanimated as their cells are immune. Susceptibles that are infected have a chance to be cured and that goes to cure rate, however if it is too late then they will already turn into zombies and cannot be cured. The zombies can die from attacks by infected, susceptibles, or immune.

2. Modelling Covid - 19 with DE Paper Analysis.

- The details of the differential equations model used in the analysis.

$$\frac{dP}{dt} = k_{RP} \times R - k_{PS} \times P - v$$

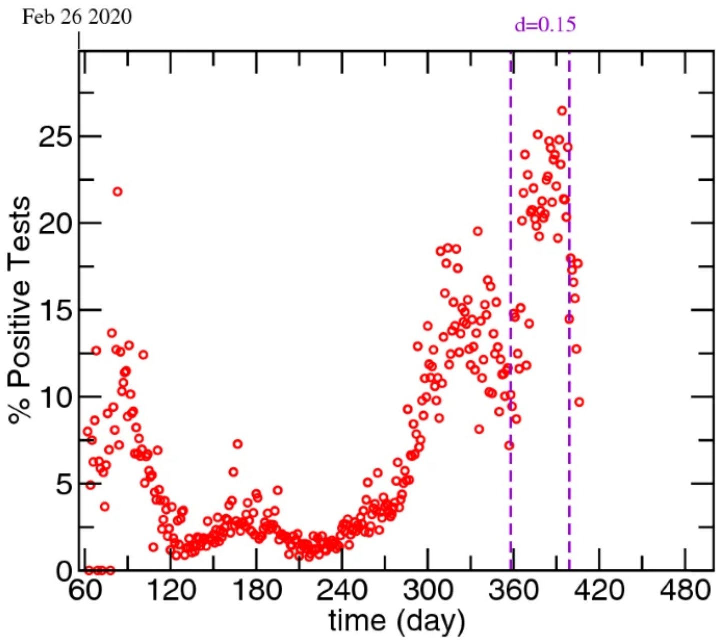
The differentiation equation of the population (P) is equal to the difference of the rate of change from recovery (R) to population by the rate of change from protected population (P) to susceptible population (S) and a constant value of daily vaccinated population.

$\frac{dP}{dt}$ refers to the rate of change of the protected population.
Rate of change from $R \rightarrow P$ is described by k_{RP} multiplied by R. Variable k_{RP} is the characteristic reinfection rate that is the constant float rate of the progression time a vaccinated person can potentially be reinfected by the Covid-19 virus. Variable R is the number of recovered population.

Rate of change from $P \rightarrow S$ is described by k_{PS} multiplied by P. k_{PS} is the transition rate that is a constant float rate for describing the transition progression time a protected population becomes a susceptible population.

- The assumptions made of the differential equations model used in the analysis.

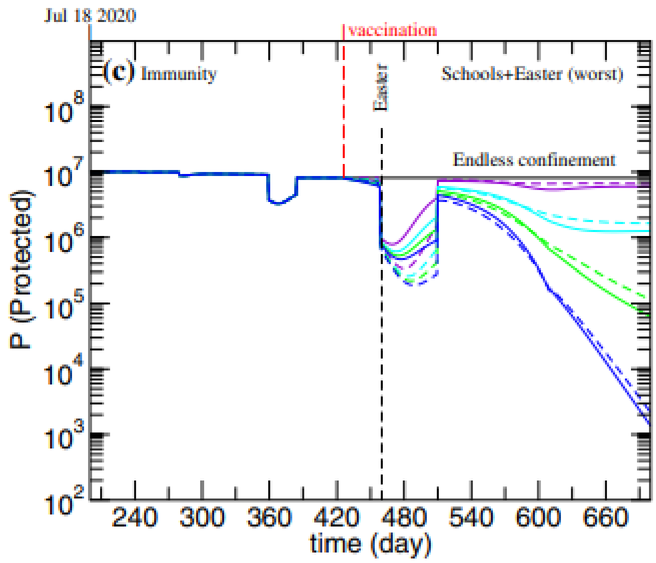
The assumption made for P compartment is the protected population described by the number of the population that is aware of the Covid-19 virus who follow sanitary and social distancing measures, either imposed by the government or self-imposed by each individual as a result of risk perception.

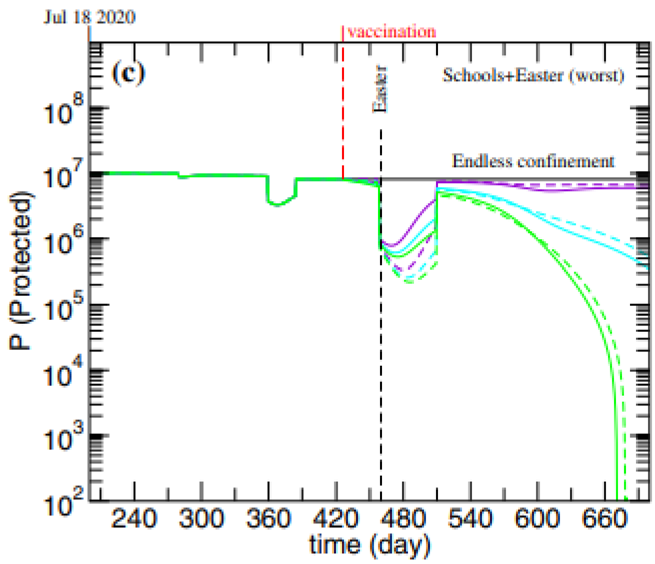


The assumption made for k_{PS} is the violet dashed lines in the figure above show the moments when the rate kPS changed.

- The accuracy of the predictions made of the assigned DE.

Based on the paper, the accuracy of the differential equation that is used based on the provided graph, the DE accuracy did follow the typical DE Solver accuracy where the more the range is increased, the more error it did. ODE Solver accuracy can be formalised as λ^{n+1}. Where λ is the ratio of t to $t + dt$ and n is the order of the DE.





We can see that at easter, the DE became inaccurate, where at day 510, the parameters are replaced with more recent data. If the values of the are correct, the accuracy of the predictions will depend on how the DE is solved numerically. DEs can be solved with a number of numerical methods, like Euler's method, Runge-Kutta methods, and finite element methods. The accuracy of the answer can depend on which numerical method is used. Methods that are more accurate tend to use more computing resources. The predictions may be based on the assumptions made in the model that the DE is based on. For example, the DE assumes that the rate of reinfection and the rate of transition are linked in a certain way, which may not be true in all cases. Then if we fit the prediction into data available, the DE is accurate in the early ranges and becomes inaccurate in the later ranges.