Modelling the Covid_19 pandemic

Version 2.0

I. Assumptions

Modelling principles used for modelling biological processes have been used in this model. This simple model consists of several differential equations and it models how the infection affects the entire Earth. It can be easily extended to regions, countries and age groups if needed. Based on our previous experience in modelling bacteria, the opposite approach of starting with modelling the countries/regions first would not bring any success.

II. Initial conditions

This table presents all the parameters used in the model for two scenarios A and B. We assume Earth to be an isotropic homogeneous closed system thus we are necessarily working with averages.

Variable	Explanation	Value
T0	Zero time. The time when the virus has been seeded.	0
T	The time period in days for the simulation	500 days
No_Seats	No of places where the virus has been seeded.	1
No_Zero_Patients	Initial No of infected people at every Seat	50
TStart	How many days after T0 did testing begin	70
TLockDown	How many days after T0 were lockdowns put in place	100
Mortality	Estimated Mortality Rate for an infected individual Not for an individual that tested positive.	0.1 %
Immunity	Proportion of people with absolute immunity during the outbreak	5 %
Population	World population	7 000 000 000

Model variables and their initial values

Variable	Explanation	At T0
Infected	Number of infected people	50
Healed	Number of healed people	0
Dead	Number of dead people	0
Tested	Number of Tests conducted	0
T_Infected	Number of positive tests	0

Cure Types – Cure 1&2 are available in the model. Cure 1 takes its part in an example below.

Cure Type	Explanation	Applies to	Days to heal
Immune	Percentage of people who are absolutely immune during the outbreak	5 %	0
Cure 2	First type of cure	0 %	4
Cure 1	Second type of cure	0 %	-
No cure	Natural healing	95 %	40

Applies to: what percentage of infected people are being cured by the given cure.

Infection rate, i.e. how many people does one infected person infect per day. The numbers are relatively high, 50 before lockdown, to account for extensive travel by air and mixing of people in crowded public spaces: departure halls, educational institutions, air-conditioners effects etc. During lockdown, 5 (seemingly large) was chosen to simulate countries which have not imposed drastic lockdown measures, travel measures and social distancing measures. We are modelling the entire Earth, so these numbers are necessarily averages.

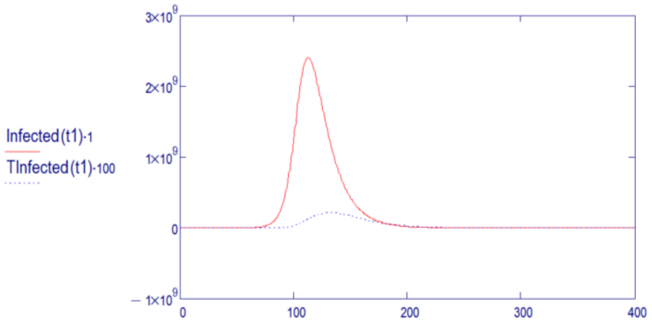
Based on assumptions and initial conditions given above, the model has produced the following results. It must be kept in mind, that these results are only trend indicators. Although the results are quite similar to real figures published by WHO, this model must not be taken as an accurate simulation of reality.

III. Calculations

In this indicative stage of the model only relative results showing trends can be expected. This is a good time to get real data collected from the terrain data and calibrate the model with those. When it starts producing results comparable with the real-world situation, then it can be moved to the next stage. Following calculations just show how the model responses to some interesting scenarios:

III.1 Model's response to imposing lockdown

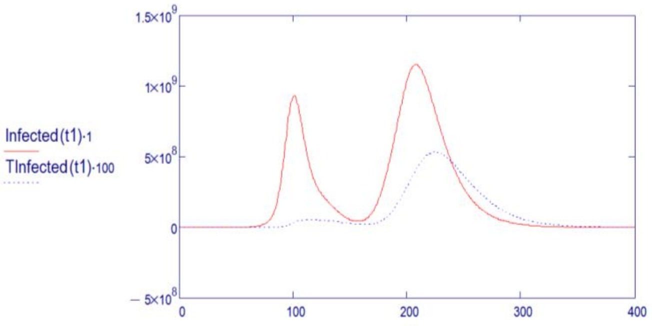
Scenario A: no lockdown put in place			Scenario B: Lockdown at T0 + 3 months	
Time period	Infection rate (ppl.day^{-1})		Time period (days)	Infection rate (ppl.day^{-1})
T0-400	50		T0 – 90	50
			90 – 150	5
			150 – 400	50



$\text{Infected}(120) = 2.102 \times 10^{9}$

$\text{Tested}(120) = 2.027 \times 10^{7}$ $\text{Healed}(120) = 3.755 \times 10^{9}$

$\text{TInfected}(120) = 1.784 \times 10^{6}$ $\text{Dead}(120) = 2.102 \times 10^{6}$



$\text{Infected}(120) = 3.061 \times 10^{8}$

$\text{Tested}(120) = 2.027 \times 10^{7}$ $\text{Healed}(120) = 1.58 \times 10^{9}$

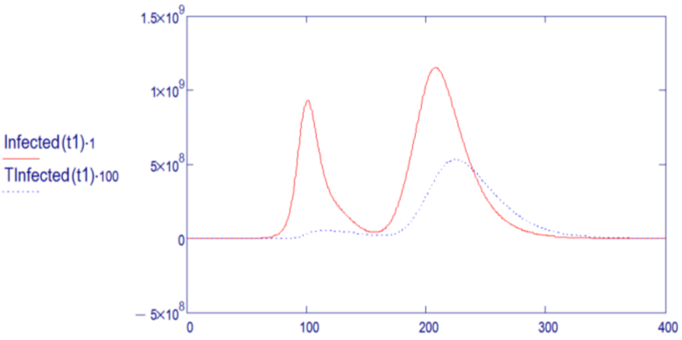
$\text{TInfected}(120) = 5.485 \times 10^{5}$ $\text{Dead}(120) = 3.061 \times 10^{5}$

It is clear that the number of positively tested is higher during the second wave of the pandemic due to widespread testing and better testing methods. B scenario raises the question, is it really possible for another huge peak of the pandemic to happen?

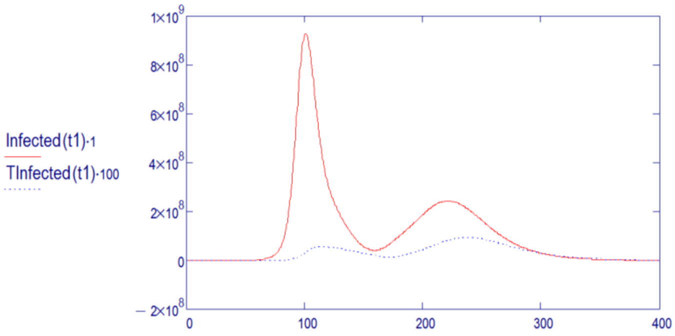
III.2 Model's response to a new cure

The model answers some logical questions about what happens when different approaches to handling the epidemic are applied. Another approach is the widespread use of a new cure. In the following we assume a cure which is deployed to 25% of the population and it takes 4 days for an infected to heal and become immune. The cure was deployed at the end of the lockdown, i.e. at T=150 days. It should downsize the second peak:

No Cure with lockdown:



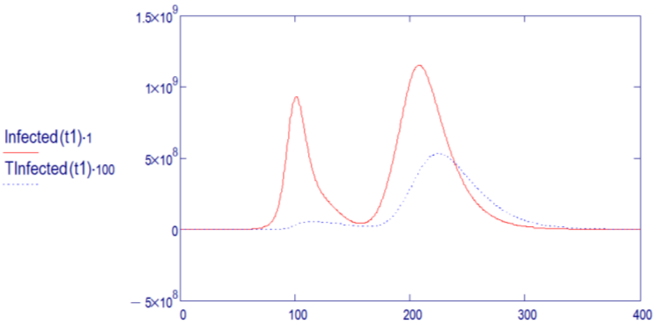
Cure Applied:



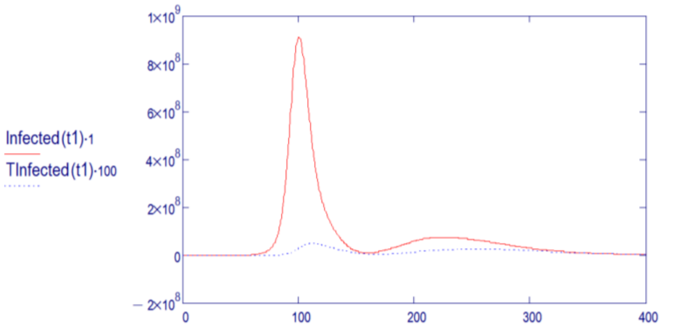
III.2 Model's response to a gradual increase of immunity

The last example shows how the second peak changes when the total immunity of the population grows linearly from 5% to 14 % during the period 100 - 200 days:

No increase in immunity:



Increase in immunity at T=100 - 200:



The second peak will last longer and will be much lower.

IV. What are the tasks ahead?

	Task	Owner and activity
T1	Is this model worth developing further?	We do not know an authority to be happy with a further development
T2	Is the set of equations and processes correctly implemented?	Mathematicians, physical chemistry engineers who have experience in modelling from the global perspective. Epidemiologists, social experts, … to investigate the kinetics of the model.
T2	Calibration of the model. Using the real-world data, reverse engineering the initial parameters.	Mathematicians
T3	Incorporating countries, regions, age groups etc. but keeping the philosophy of the model intact	Different mathematical tool must be used. A huge set of differential equations is expected.
T4	Use the model in policy setting	Politicians.

When the model is calibrated, the T0 date as well as other important constants can be clarified.

V. Final Remarks

Perhaps the most important question – and the purpose of such model– is: Where on the graph are we now? In other words, what are the real T0 and TStart dates?

VI. Acknowledgement

We have applied our general mathematical and chemical engineering approach to the COVID-19 issue. The whole approach is based on modelling waste-water treatment processes. The roots of this approach were laid in the early 90s at the University of Cape Town (Prof. George Ekama) and the Prague Chemical University (Prof. Peter Grau).

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