**Program Structures & Algorithms**

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**Covid-19 Simulation**

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**Introduction**

This project aims to simulate the spread of a virus such as Covid-19 or SARS. The simulation takes into account of basic reproduction number, mask usage, vaccine availability, barrier actions, prevalence of testing and contact tracing, population and recovery.

**Guidance**

We designed a user interface to allow soft coding from users and execute the program. The main entrance shows as below:

<img>

User can execute the program by clicking “Run”, set the default value by clicking “Default” or clean all the inputs by clicking “Clear”.

Then it will pop up a page with figures of simulation result.

**Algorithms & Assumptions**

The basic idea is to modify R0 corresponding to the external and internal variants. Core formula is:

where R is the combination of R0 and all variants.

We count new case at the end of every day and renew the input variants for next status.

Variants

1. Mask

We have two soft coded variants as “Up Limit” and “Effectiveness”. Both values are between 0 and 1. The formula is:

where usage is determined by:

*e = if day < 100 else 1*

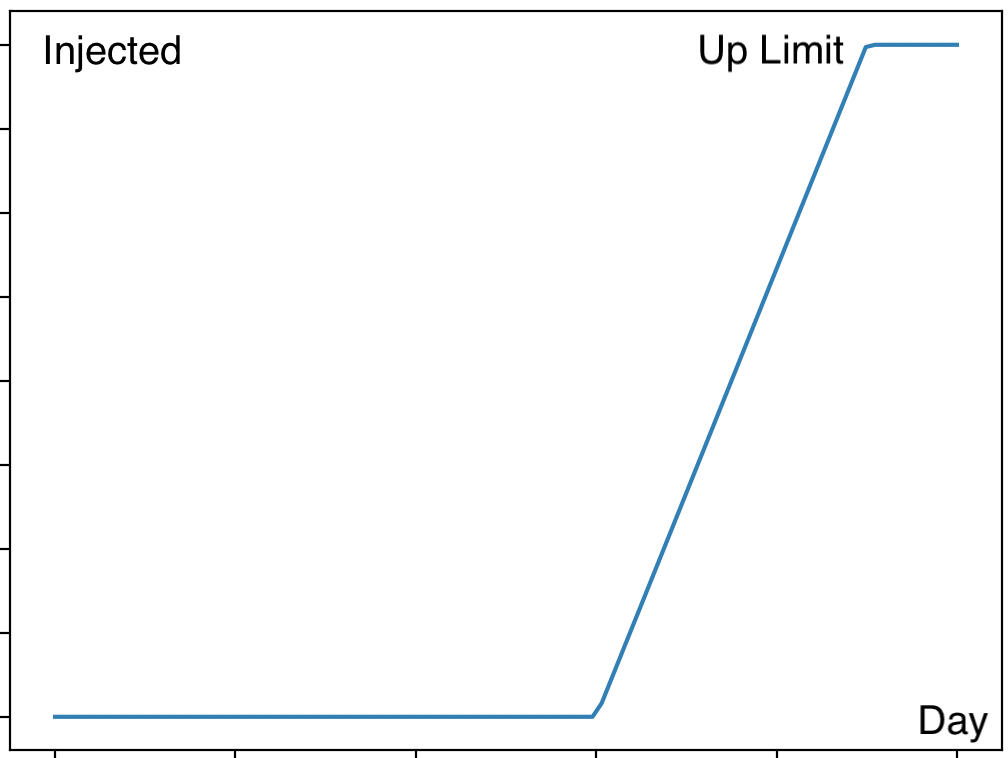
“day” is the spanning day from simulation begins. “TOTAL PPL” is total population as an invariant in this simulation.

This is to consider people raise the attentiveness when day goes by and case number goes up.

2. Vaccine

Four soft coded variants: “Up Limit”, “Efficacy”, “Created Day”, and “All Injected Day”

Before “Created Day”, there are no people injected of vaccine. After “All Injected Day”, “Up Limit” of people get injected considering some would not like to take the vaccine. The popularizing progress is linear. It goes like this:



And the effect to R is like:

3. Barrier

In this case, we consider two measures – “Quarantine” and “Ventilation”. “Quarantine” is parted into “Susceptible” and “Patient” due to different medications to the crowd. We will count “Patient” in Recovery later. The basic formula is:

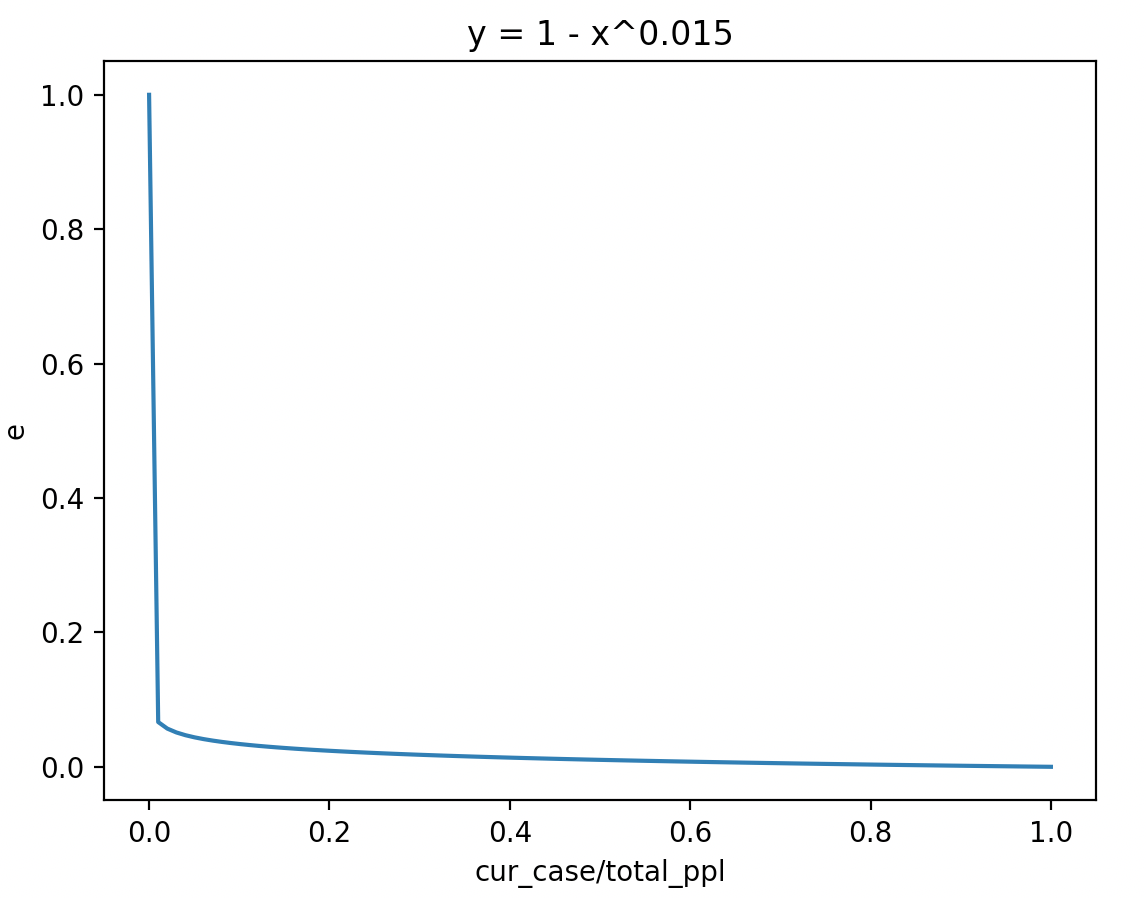
4. Test & Trace

We have four variants, “Test Efficiency”, “Test Percentage”, “Trace Efficiency”, and “Trace Percentage”. Like Barrier, it goes like:

5. Population

When infected case goes up, the spread of virus would get faster due to the large patient crowd. However, when it comes to certain level, people raise the attentiveness and be more conscious of protection. Thus, the proportion would be smaller.

Y = 1 – X^0.015 goes like this:



When virus just exploded which means current case is small, we assume most of people would be careful about that so the reproduction number drops significantly. However, there are still remaining part that go to party regardless of the pandemic. The case number does little to their lifestyle. So population limitation drops slowly afterwards.

6. Recovery

Patients would recover from Covid-19 due to the quarantine or other medications. We suppose an average recovery day in this case as “Cure Need Days”. Other variants go like “Cure Percentage” and “Quarantine Effectiveness of Patient”. When we do good medications and quarantine, the “Cure Percentage” raise up.

And we add arbitrary factor to cover those unexpected situations:

The Random Percentage is set up to 0.05.

**Output**

Here we provide with an example of an anonymous viruswhich R0 is set up to 15. It shows an obvious change: <https://youtu.be/Wj48V1YD-8c>

Here are animated pie charts of Covid-19 and SARS

[<animated pie chart of Covid-19 R0 = 2>](https://youtu.be/rMSMOSxsACw)

[<animated pie chart of Sars R0 = 3>](https://youtu.be/0NyIeBcWkn8)

图表, 折线图

描述已自动生成<example line graphs of anonymous virus R0=15>

图表, 折线图

描述已自动生成<line graphs of Covid-19 R0=2>

**图表, 折线图

描述已自动生成**

<line graphs of SARS R0=3>

**Mathematical Analysis**

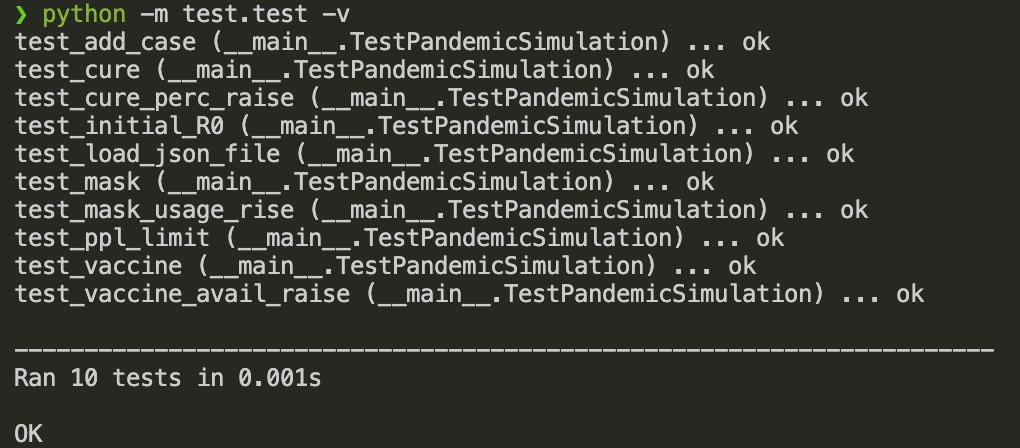
Compare two virus,

**Conclusion**

The rapid spread of coronavirus disease 2019 (COVID-19) creates significant challenges for economies and healthcare systems of many countries around the world. The situation evolves extremely quickly and, to date, there is a high degree of uncertainty about the future outcomes of the pandemic.

In this report, we examine how the likelihood of reinfection affects epidemiological dynamics at the population level of 0.3 billion. A key finding is that mitigation measures not only delayed the peak of infection, but also delayed the moment when the difference between reinfection and non-reinfection options became apparent.

**Unit tests result**

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