Policy Development for COVID-19 Pandemic Response Using System Dynamics

Charlle Sy[1,4*], Ezekiel Bernardo[1], Angelimarie Miguel[1], Jayne Lois San Juan[1,4], Andres Philip Mayol[2,4], Phoebe Mae Ching[3], Alvin Culaba[2,4], Aristotle Ubando[2,4], Jose Edgar Mutuc[1,4]

[1] Industrial Engineering Department, De La Salle University

[2] Mechanical Engineering Department, De La Salle University

[3] Department of Industrial Engineering and Decision Analytics, Hong Kong University of Science and Technology

[4] Center for Engineering and Sustainable Development Research, De La Salle University

*email: charlle.sy@dlsu.edu.ph

System Dynamics

Modeling Framework

System Dynamics (SD) is a simulation and modelling technique that is used for strategic planning

It has been employed in disease outbreaks such as influenza.

It is a comprehensive systems perspective approach to map relationships present within complex systems

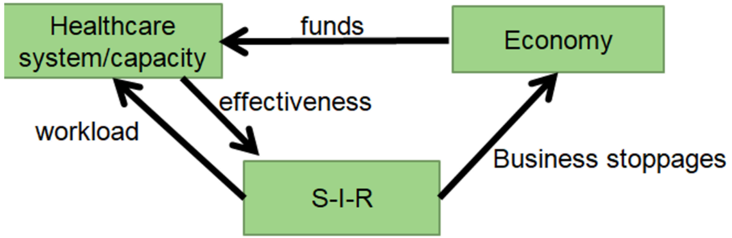
- The framework developed in this study builds upon the basic Susceptible-Infectious-Recovered (SIR) model by Grassly and Fraser (2008).
- Modeled the natural infection process, the number of infected persons- divided into the asymptomatic and symptomatic

Evaluate the impacts of various policy actions adopted by the government.

Effectiveness is evaluated in terms of the number of infected people in a population- gravity of the pandemic

Modeling Structure

- The SIR model is extended to include its interactions with the economy and healthcare sector
- The model looks at how COVID-19 relates to economic pressure, stress on the healthcare system, etc.

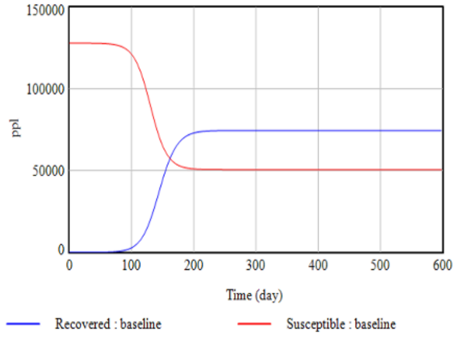


Baseline Simulation

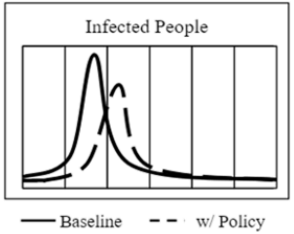
Adopted Policies

Recovered vs Susceptible

- Baseline simulation establishes model validity
- Everyone is susceptible to COVID-19 at the start. As more get infected, number of susceptible decreases through time.



Increase Healthcare System Capacity



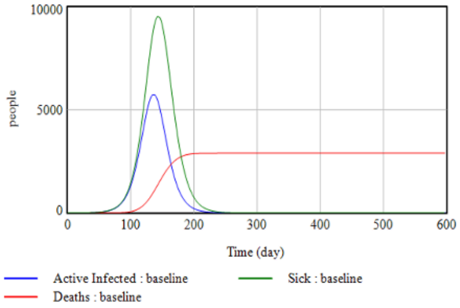
For countries with sufficient capital, **the construction of additional hospitals and quarantine centers** were among the primary responses adopted.

However, the simulations show that the improvement on infection rates will be **insubstantial.**

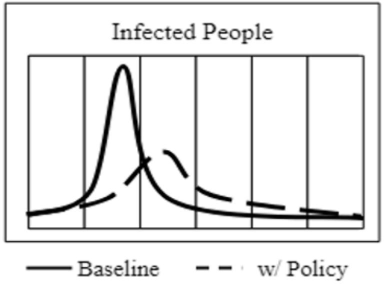
Without other policies to control contact, the healthcare system will simply be overloaded.

Infected, Active Cases and Deaths

- Delay between infections and deaths
- Both infections and sick are expected to peak at a certain point and subsequently decrease
- Deaths are expected to flatten eventually without any intervention



Social Distancing

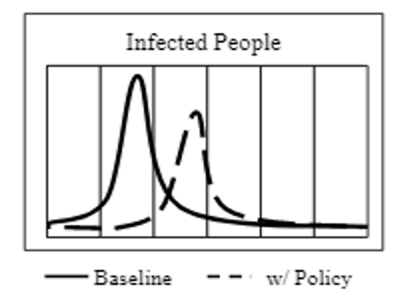


- Social distancing either through education, publicity, or the closure of establishments
- **This reduces the peak levels of infection but also extends the duration of an affected country**.
- This policy has **detrimental effects to the economy.**

*The SD model has been implemented in the software Vensim. This programming language can be acquired from Ventana Systems, Inc. (www.vensim.com). The manuscript and model itself is available from the lead author upon request.

E x t e n d E C Q ?

- Policymakers can control the ECQ period, as best befits their situation.
- The simulations show that this run the risk of merely delaying the peak of infection, without significantly reducing the number of infections.



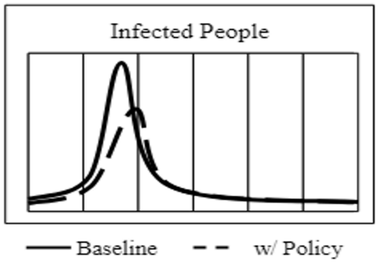
ECQ can completely "starve" the virus for the **duration of the lockdown**.

However, this lengthens the amount of time it will take to recover from the virus.

Beyond a certain limit, extending the quarantine period will make no further improvement on the infection rate.

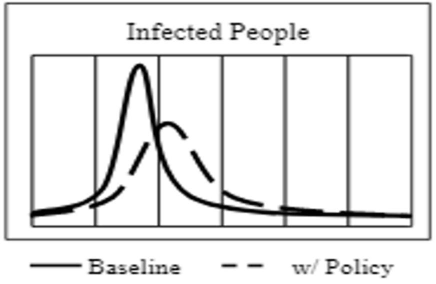
Economic pressure will force the lifting of ECQ

Lifting ECQ with precautionary measures against infection



- Yielding to economic pressure will raise the infected fraction of the population
- But coupled with precautionary measures against infection, this will be less than the baseline

Selective ECQ - specific demographics



- Demographic with lower mortality rate will be allowed to work as usual.
- The infection is not significantly lower than yielding completely to economic pressures.

Gradual lifting of ECQ

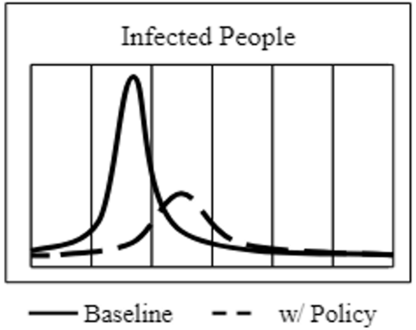
- Shows the benefits of considering synergistic/complementary policies
- Gradual lifting of ECQ maintains precautionary measures (social distancing, wearing of masks, etc) but allows economic activity to continue
- It reduces chances of infection and limits consequences to economy
- Rather than “starve” the virus from ECQ only to have a second wave, infections are managed and “spread out”
- Reduces strain on healthcare systems. Prevents overloading of hospital capacity

The COVID-19 outbreak has proven to be a complex problem with effects rooted in public health and economics among important factors.

It is critical that deeper analysis and assessment frameworks are investigated to support decision-making for risk management strategies and transmission control interventions

It is important to consider that countries, even those that implemented the same response to the pandemic, have done so with varying degrees of stringency, or have used different subsets of policies in response to the situation. This may change the behavior of infection further, with some policies being synergetic or supplementary to each

- A variation being considered for this policy is to lift ECQ gradually.
- Gradual relaxation of rules
- Observation: significantly reduced the amount of infections taking place- very low peak with the length of the pandemic being the same



The most effective strategies focus on **avoiding exposure to the virus from happening in the first place**

Focusing on increasing healthcare capacities only **delay the inevitable system collapse**

System dynamics provides an **understanding of relationships of the stakeholders in the system-** LGU, hospitals, etc