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RISK MANAGEMENT ARTICLE

A Quantitative Method for Modelling COVID-19 Risk

COVID-19, as many of us now know, is an airborne respiratory illness which is caused by a coronavirus (SARS-CoV-2). The disease was first identified in December 2019 and rapidly swept across the globe through 2020. In early 2020 (and even today), there was a lot of debate about the severity of the disease and its fatality rate. There is some data available for countries which were hard hit early (South Korea, China etc.) but due to reporting differences and other confounding factors, a lot of uncertainty surrounded this risk.

We have also seen that many models have been used, especially, by various governments around the world to take policy decisions such as ordering supplies, building field hospitals etc. In this article, we will explore how such a model is created using Monte Carlo Analysis - a proven technique for quantitative risk assessments.

Monte Carlo Analysis allows us to assign a range to uncertainty and based on the created model, provides us with the most likely outputs of risk realization. Let us apply a simple step-wise approach to come up with a simple model for predicting deaths due to COVID-19 and number of

people infected in the United Kingdom.

The aim of this article is not to predict the risk but to show how a model is made and what parameters go into it, especially to show the power of Monte Carlo analysis in probabilistic risk modelling.

Even though this model is much simpler than those officially published, validated and used around the world, the outputs are quite within range of generally accepted models.

Step 1. Parse the system under study in terms of input variables and output variable.

Input variables:

- a) Population of U.K
- b) Infectiousness or spread of the virus
- c) Mortality rate of the infected people (Case Fatality)

Intermediate Output variable:

- d) Number of people

Final Output:

- e) Number of deaths

Step 2. Choose probability distribution of X variable

- a) Population of U.K – Fixed
- b) Infectiousness – Triangular (assuming infectiousness reaches a peak value and declines)
- c) Mortality rate of infected (Case Fatality) – Triangular

* Triangular distributions are easy to use when we do not know mean and standard deviation. In real life, this is may not be the case and the case fatality equation and spread would be a complex model in itself.

Step 3. Assign limiting values based on the probability distribution

- a) Population – Fixed – 66.65 million
- b) Infectiousness – Triangular - Lower = 0.002, Mode = 0.005 Upper=0.006
- c) Mortality Rate of infected – Uniform - Lower = 0.01, Mode = 0.12 Upper=0.15

* Assigned parameters based on available data as of 4/23/2020

Step 4. Choose Y variable (output)

Intermediate Y

- a) Number of People Infected

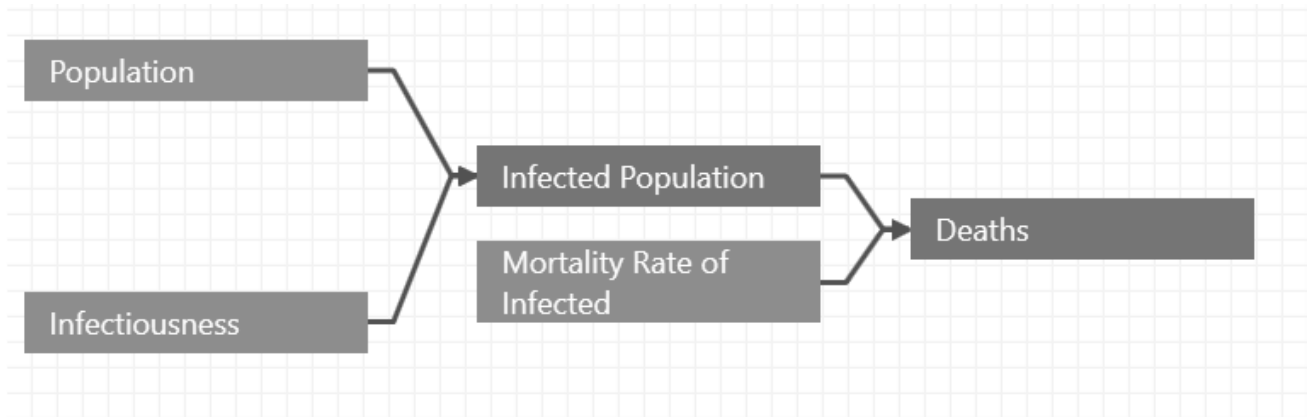
Final Y

- b) Deaths

Step 5. Define Model

Total number of Deaths from COVID-19=

[(Population of U.K) X (Infectiousness)] X [Mortality Rate of Infected People]

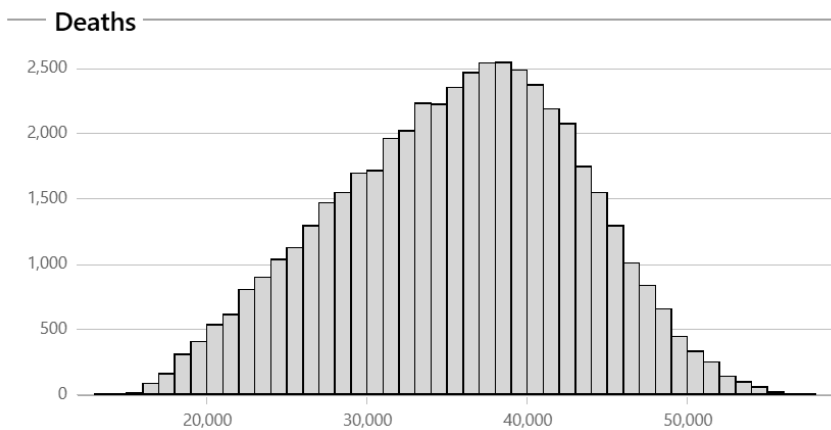


X Name	Distribution	Parameters	Preview
Mortality Rate of Infected	Triangular	Lower: 0.1, Mode: 0.12, Upper: 0.15	
Population	Fixed	Value: 66,650,000	
Infectiousness	Triangular	Lower: 0.002, Mode: 0.005, Upper: 0.006	

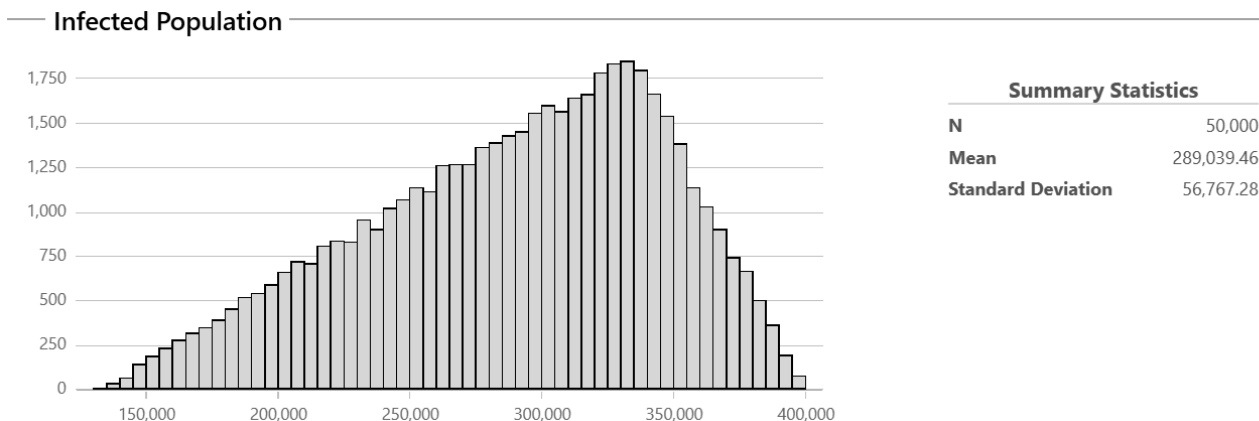
Step 6. Run simulation

Output at 50,000 cycles:

Output (Y)



Summary Statistics	
N	50,000
Mean	35,616.13
Standard Deviation	7,604.22



Step 7. Adjust parameters as needed

The simple model shown above estimates the total deaths in the U.K to be 35,617 with a standard deviation of 7605 while it shows the number of people infected to be 289,040 with a standard deviation of 56,767.

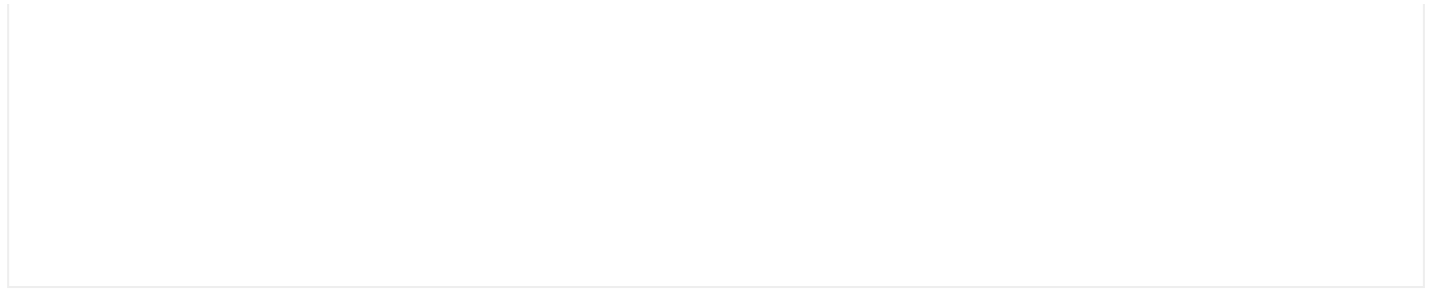
This model uses input parameters like case fatality rate and infectiousness which are based on data from regions which experienced the virus earlier than U.K and which had slightly different responses to infections. Thus, as more data becomes available, parameters like 'Infectiousness' would have to be varied based on effectiveness of measures to mitigate the virus such as social distancing, wearing of masks and gloves etc.

A sensitivity analysis can be carried out and model can be updated if 'mortality of infected' or case fatality rate can be decreased by better treatments and other measures. Similarly, based on other factors such as regional herd immunity, vaccines and new or experimental treatments, the parameter of case fatality rate along with infectiousness can be modulated based on available evidence based assumptions and the model can be updated as the issue progresses.

To reiterate, the aim to this article is to present *how* to model a risk using Monte Carlo analysis using a simple model. The data from this article should not be used for decision making purposes. The data is real but is being used in analysis for concept building purposes (for the Monte Carlo tool) only.

About the author:

Jayet Moon is a Senior ASQ member and holds ASQ CQE, CSQP and CQIA certifications. He has earned a Master's degree in Biomedical Engineering from Drexel University in Philadelphia and is a Project Management Institute (PMI) Certified Risk Management Professional (PMI-RMP). He is also an Enterprise Risk Management Certified Professional (ERMCP) and a Risk Management Society (RIMS) certified Risk Management Professional (RIMS-CRMP); a certification which holds official accreditation from American National Standards Institute (ANSI) under ISO/IEC 17024:2012.

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