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சுகாதார மேம்பாட்டுப் பணியகம்
Health Promotion Bureau

Ministry of Health
Sri Lanka

An Extended Susceptible-Exposed-Infected-Recovered (SEIR) Model with Vaccination for Forecasting COVID-19 Pandemic

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01. Introduction

○ The role of modelling in predicting the spread of an epidemic is important for health planning and policies.

This study was aimed to apply a compartmental model for predicting the variations of epidemiological parameters in Sri Lanka.

02. Methods

○ Model:
Dynamic Susceptible-Exposed-Infected-Recovered-Vaccinated (SEIRV) model and simulated for potential vaccine strategies under a range of epidemic conditions during 2021

- ○ Programme language: Python
- ○ Observed how the dynamics influenced the SEIRV model without COVID-19 vaccination at different R0 values, and estimated the duration, exposed, and infected populations
- ○ The predictions based on:

1. Vaccination coverages (5% to 90%), vaccination-rates (1%, 2%, 5%) and
2. vaccine-efficacies (40%, 60%, 80%) under different R_0 (2, 4, 6)

○ Model equations

The flow of individuals through the compartments of the model is governed by a set of Ordinary Differential Equations:

$$\frac{dS}{dt} = -\beta I \left({}^{S}/_{N}\right)^{\alpha} - \delta\varepsilon S$$

$$\frac{dE}{dt} = \beta I \left(\frac{S}{N}\right)^{\alpha} + \beta I \left({}^{V}/_{N}\right)^{\alpha} - \sigma E$$

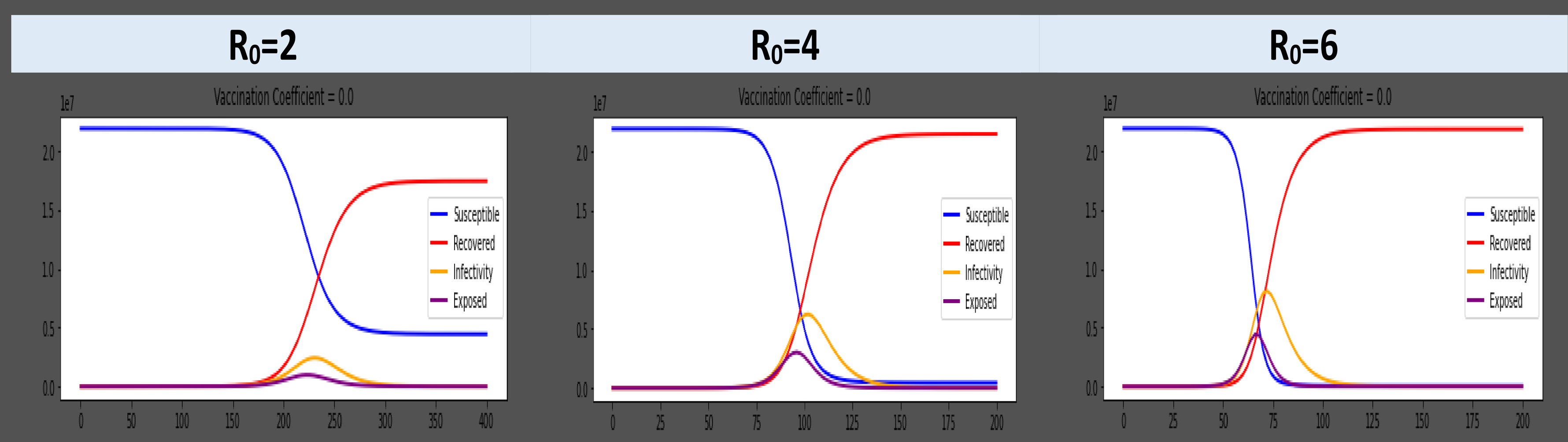
$$\frac{dI}{dt} = \sigma E - \gamma I$$

$$\frac{dR}{dt} = \gamma I + \varsigma V$$

$$\frac{dV}{dt} = \delta\varepsilon S - \beta I \left({}^{V}/_{N}\right)^{\alpha} - \varsigma$$

03. Results

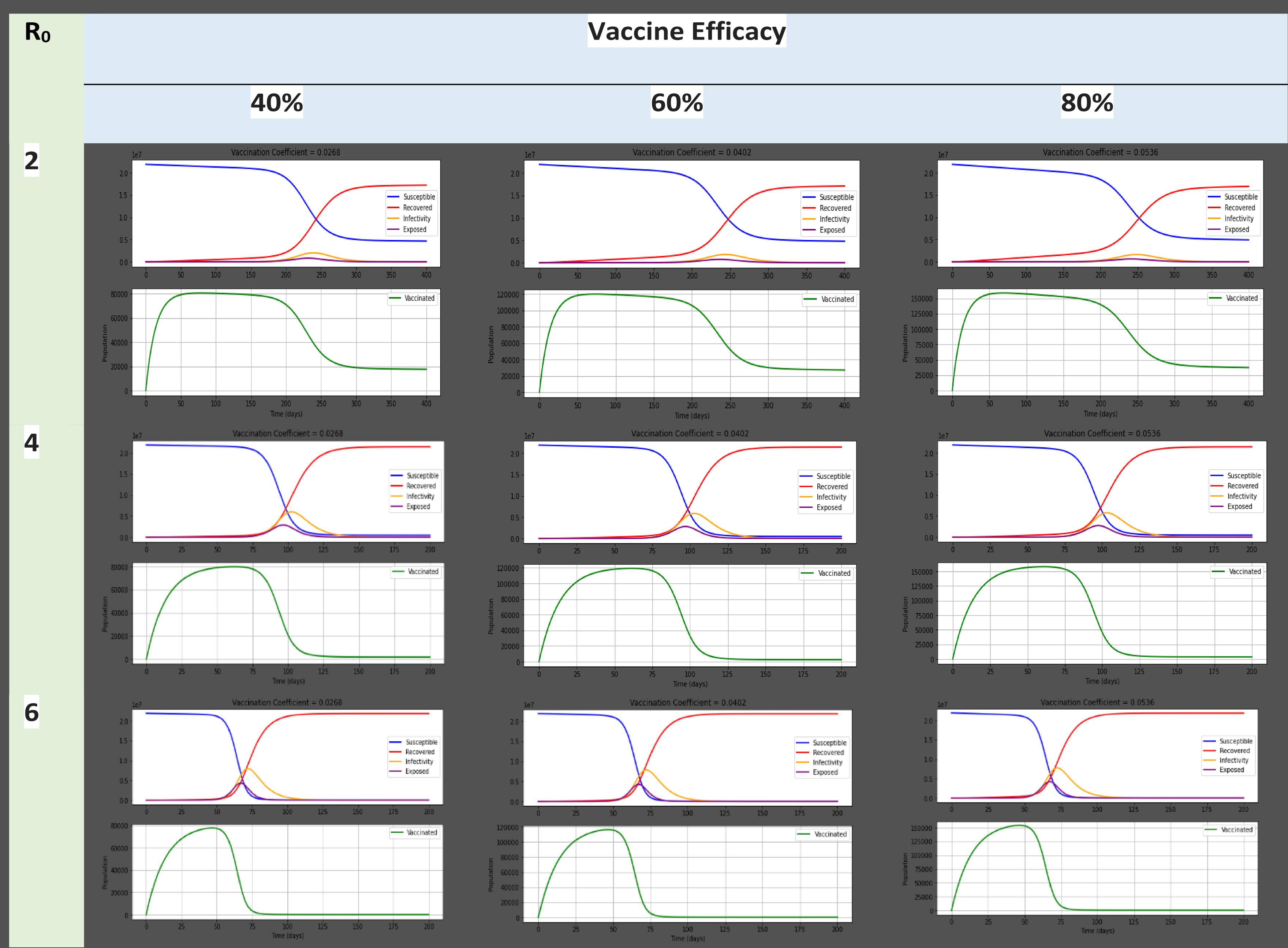
○ Figure 1: Evolution of infectious proportion without vaccination with different R_0 values



○ Table 1: Relationship between different vaccination coverages with the infected population and time of peak arrival

Percentage of vaccine coverage	Proportion infected out of Susceptible (21.9 Million)	Time of peak arrival
5%	6.80%	Day 40
15%	2.70%	Day 30
30%	1.80%	Day 25
45%	1.60%	Day 22
60%	1.50%	Day 21
75%	1.45%	Day 20
90%	1.44%	Day 19

○ Figure 2: Prediction based on the SEIRV model considering the parameter R_0 and vaccine efficacy variation
(Vaccine efficacy=40%,60%,80% and R_0 =2,4,6)



04. Conclusion

- ❑ Computational model for predicting the spread of COVID-19 by dynamic SEIRV model has been proposed.
- ❑ If a vaccination campaign is successfully implemented, this will undoubtedly impact the selection of the R_0 and consequent infection rates in that country.
- ❑ The vaccination offers greater benefits to the local population by reducing the time to reach the peak, exposed and infected population through flattening the curves.

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