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Simulation Analysis and Forecasting of COVID-19 Spreading in Malaysia

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Abstract: Coronavirus disease 2019 (Covid-19) is known as a disease caused by a novel coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2; formerly known as 2019-nCoV). The deaths caused by coronavirus continue to increase the mortality rate by about 5% due to the wide spread of the disease geographically[5]. Based on Kermack and McKendrick (1927), their plague model, is considered one of the earlierst model for a system of four ordinary different equations. This study aimed to develope and simulate the Susceptible-Exposed-Infected-Recovered (SEIR) model of Covid-19 using Python software. Python software was used to analyze the spread of the pandemic in Malaysia. Next, this research also forecast the infected and recovery of Covid-19 cases in Malaysia using Microsoft Excel. The results showed the graph of infected and recovered from 25 November 2022 to 31 March 2023 is reduced and close to zero.

Keywords: SEIR Model, Covid-19, Python Software, Forecast, Pandemic, Analyze, Spread, Microsoft Excel

1. Introduction

In early December 2019, an unknown virus was infecting the human population in Wuhan after a local hospital reported multiple pneumonia cases [1]. By 8th January 2020, Chinese health officials has detected a new virus related to the illness epidemic, known as novel coronavirus (nCoV) infected pneumonia, which would eventually be recognized as Covid-19 by World Health Organization (WHO) [2].

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Since 25th January 2020 over 6,000 people in Malaysia have been infected by the Covid-19 virus. 18th May 2020 a total of 113 deaths have been reported. Malaysia has introduced many non-pharmaceutical intervention (NPI) techniques to fight the pandemic, including the Movement Control Order (MCO), which was first applied on 18 March 2020 [3]. The MCO, as well as other measures including social separation, isolation, and quarantine, were designed to break the Covid-19 transmission chain in Malaysia. These procedures were taken to flatten the epidemic curve and prevent an exponential increase in new Covid-19 infections, allowing for successful pandemic management and control. Covid-19 case patterns must be accurately forecasted for health system to be prepared for outbreak management and resource planning. Infectious illness mathematical and statistical modelling are powerful techniques that can help health system predict future disease patterns [4].

Endemic viruses, on the other hand, are presented and have a fairly predictable spread. This predictability allows healthcare systems and physicians to prepare and adapt, thereby reducing loss of life [5]. Therefore, forecasting the path of this outbreak is necessary for future planning of the control measures that must be done. The numerous measures have been taken to defend against the virus, and the Covid-19 booster are one of them. The Malaysia government providing free vaccination shot such as Pfizer- BioNTech/Comirnaty, AstraZeneca and Sinovac-CoronaVac to its residents. In the time being, the vaccination programme includes the addition of booster shot. Research analysis showed that the combinations booster with second vaccine can help to lower the risk of infection [6].

There are three objectives for this research, firstly, to simulate of Covid-19 spreading in Malaysia using SEIR model. Secondly, to compare the data of spreading Covid-19 in Malaysia from 24 November 2021 until 24 November 2022. Lastly, to forecast the infected and recovery progress of Covid-19 from 25 November 2022 until 31 March 2023.

The Susceptible-Exposed-Infection-Recovered (SEIR) model is commonly used to study the transmission of infectious disease with extended incubation periods. The Susceptible- Infection-Removed (SIR) model is the simplest and basic models while SEIR model is an extension of SIR model. Individuals who have been exposed to the virus but have not yet been infected are included [2]. This study focuses on the rate of growth of Covid-19 in Malaysia by applying the SEIR model using Python. The data for Covid-19 was mainly obtained from the Ministry of Health (MOH). SEIR is a common example that takes the incubation period into account. The SEIR, an extensively used epidemic model, can reflect the flow of people between four states susceptible, exposed, infectious, and recovered. The data was taken from November 2021 until November 2022. The growth of Covid-19 would be identified using the simulation model, and the progression of this infectious condition may be predicted. Aside from that, a comparison of the SEIR model before endemic and after endemic are performed.

One of the ways is by forecasting the Covid-19 growth using the Microsoft Excel to determine the progression of infected and recovery from Covid-19 in Malaysia. It can represent both stationary and nonstationary time series and produce reliable forecasts based on the historical data.

The significance of this study is to describe Malaysia's spreading of Covid-19 based on the SEIR model. This can facilitate a better forecast of the progression of Covid-19 to prevent the cases increasing and becoming worse day by day. Furthermore, this research will increase public awareness about the importance of vaccines and boosters for people's health. The public understanding can be increased from the presentation and comparison from infected cases between berfore endemic and after endemic.

2. Materials and Methods

The SEIR mathematical modelling on the spread of Covid-19 is studied in this paper. Forecasting will also be carried out to control the infected and recovered patients of Covid-19.

2.1 Data

The data from Ministry of Health (MOH) website as used in this study to examine of Covid-19 in Malaysia to verify the SEIR model in applying to real data. The data obtained consists of the number of susceptible, the number of exposed and the number of infection and the number of recovered per day. In addition, the raw data was used to forecast the progression of Covid-19 between 25 November 2022 until 31 March 2023 using the Microsoft Excel. The data will be compared from the graph analysis perspective by using Excel. This indicates that Covid-19 infection is decreasing as the majority of Malaysians have taken a booster dose.

2.2 Formulation of SEIR Model Equation

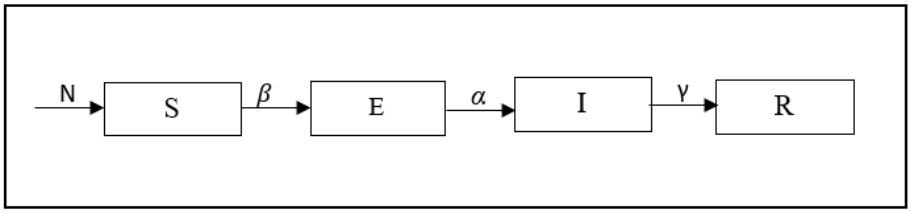

Figure 1: Scheme of the SEIR model transmission for Covid-19 [2]

Based on the population scheme of the SEIR model transmission for Covid-19 in Figure 1 [2], the rate of change in the number of people suspected, exposed, infected and recovered over time in the SEIR mathematical model of the spread of Covid-19 can be interpreted as follows [7]:

$$\frac{dS}{dt} = -\frac{\beta SI}{N}, \quad \text{Eq 1}$$

$$\frac{dE}{dt} = \frac{\beta SI}{N} - \alpha E, \quad \text{Eq 2}$$

$$\frac{dI}{dt} = \alpha E - \gamma I, \quad \text{Eq 3}$$

$$\frac{dR}{dt} = \gamma I \quad , \quad \text{Eq 4}$$

The parameter used in the model are given in Table 1.

Table 1: The parameter and definition for SEIR equation

Variable/Parameter	Definition
N	Number of human populations
S	Number of human Susceptible population
E	Number of human Exposed population
I	Number of human Infected population
R	Number of humans Recovered population
β	Infectious rate
α	Incubation rate
$\boldsymbol{\gamma}$	Recovery rate

For SEIR model the value of the parameter for, β, α, γ can be obtained by using the following formula:

$$\alpha = 1/\text{incubation period}, \quad \text{Eq 5}$$

$$\gamma = 1/\text{duration of infective}, \quad \text{Eq 6}$$

$$\beta = R0 * \gamma, \quad \text{Eq 7}$$

For the value of incubation period, duration of infective and R0 are takes from MOH Malaysia website.

To determine the research accuracy, the comparison between α and γ has been done by referencing others research. According to the first research the value of parameter α = 0.2, γ= 0.1 and the value of β = 0.208 [13]. The second research used the value of parameter α = 0.1, γ= 0.2 and β = 6.47 [8]. The third research used the value of parameter α = 0.3, γ= 0.1 and β = 0.3 [14].

Table 2: Value of parameters from others research

Value of parameters $\boldsymbol{\beta}$	Value of parameters α	Value of parameters γ
0.21	0.20	0.10
6.47	0.10	0.20
0.75	0.01	0.13

2.3 Forecast by Microsoft Excel

Covid-19 forecasting is an important research topic in order to assist the government and health care service in controlling the growth of the virus [8]. In Covid-19 modelling, the forecast function is useful in calculating the statistical value of a forecast made. Formula for forecast [9]:

$$=\text{FORECAST}(x,\text{known\_y's}, \text{known\_x's}), \quad \text{Eq 8}$$

Where, *x* is numerical x-value for which a new y-value is being predicted, known_y's is the independent array or range of data and known_x's is the independent array or range of data.

3. Results and Discussion

This study had investigated and simulated the SEIR model of Covid-19 spreading using Python software. In addition, this graph compares the data spreading of Covid-19 in Malaysia between 2021 and 2022 using SEIR model. Lastly, this study forecasts on progress of Covid-19 from 2023 until 2024 by using Microsoft Excel.

3.1 Simulation of SEIR Model

The comparison of spreading Covid-19 in Malaysia between 2021 until 2022 has been presented in the graph description analysis. Table 3 represents the value of parameters which have been used in the SEIR model graph for the year 2021 and 2022.

Table 3: Value of parameters used for Figure 2

Parameters	Value of parameters for 24/11/2021 until 31/3/2022	Value of parameters for 1/4/20222 until 24/11/2022
β	0.63	0.30
γ	0.10	0.20
α	0.18	0.50

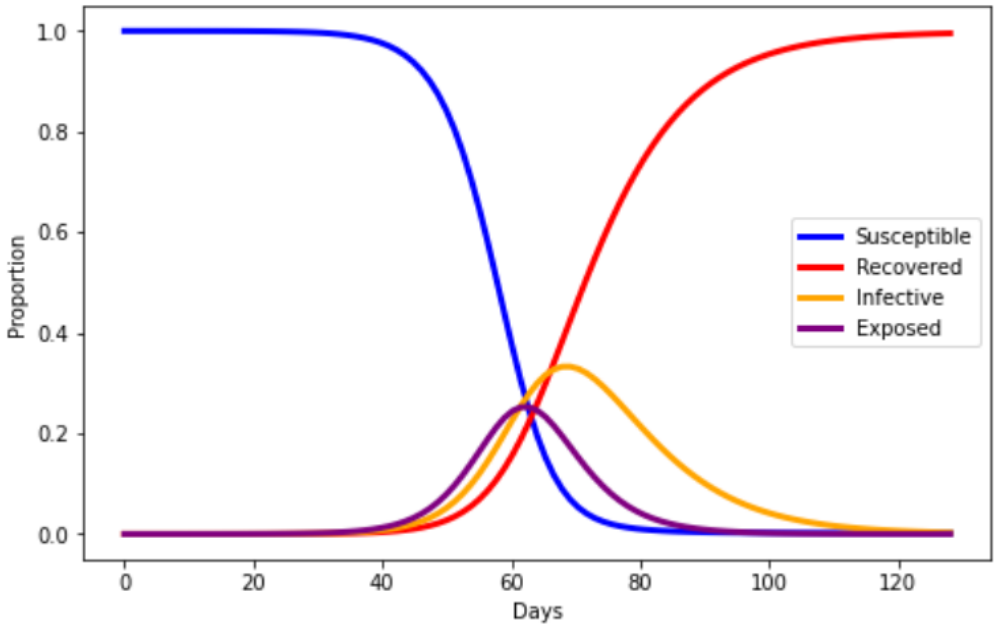

Figure 2: Time series of SEIR model from 24 November 2021 until 31 March 2022 with $\beta = 0.63$ and $\gamma = 0.1$

The results show that the value of the effective number of people getting infected each day based on MOH data. $\beta = 0.63$ and $\gamma = 0.1$ were used for this analysis. This is the graph of SEIR model before Malaysia was transition to endemic phase. On day-70, booster have been given to Malaysians according to the appointment date on the MySejahtera application.

The graph showed that, the susceptible curve has returned to approximately zero after 40 days. The susceptibility graph is decreasing because the number of Malaysians infected with the Covid-19 virus is increasing day by day. The exposed graphs grew from day-40 to day-70 before decreased after that. The exposed graph showed an increase over the number infected as there is a 1 in 10 chance of being exposed to Covid-19. This means that if one person is infected with Covid-19, it is possible to spread other 10 people. The infected graphs similarly displayed the same shape variation, however after day-70, the infected graph's growth gradually declined. Graph infected showed decreased after Malaysians received a booster shot for the Covid-19 virus [10]. Lastly, on day-40, the recovered graph is increased and remained constant. The Figure 2 is slowly recovering and approaching 1, showing the effectiveness of booster doses and SOPs such as obligation the use of face masks, requiring employees to work from home if infected with Covid-19 and practicing social distancing.

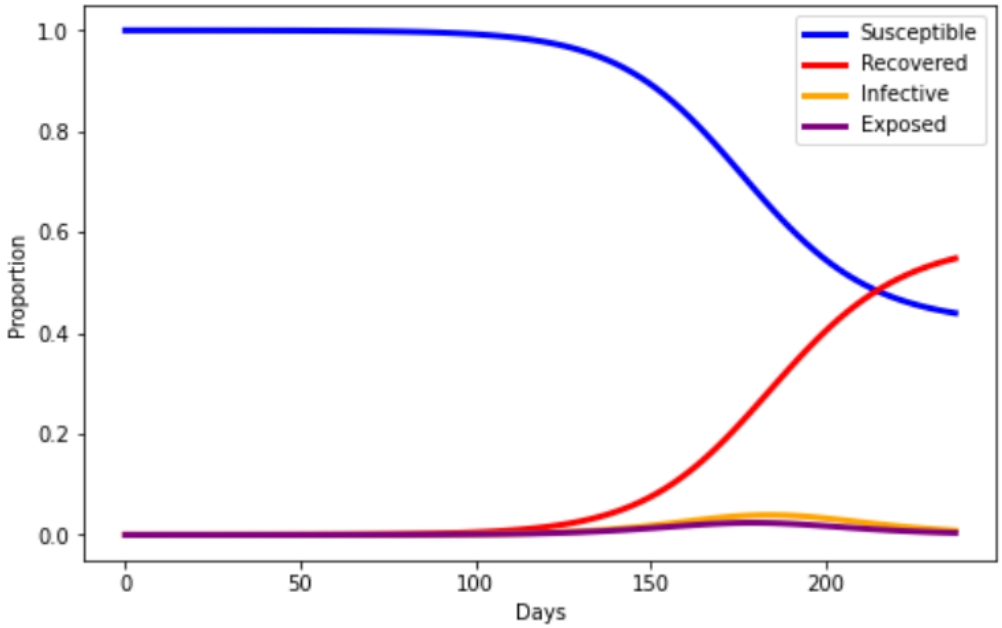

Figure 3: Time series of SEIR model from 1 April 2022 until 24 November 2022 with $\beta = 0.3$ and $\gamma = 0.2$

Figure 3 showed the SEIR model graph from 1 April 2022 to 24 November 2022 after Malaysia transition to endemic phase. The susceptibility graph started decreased at around day-100. This is because a booster dose was given and the number of people to be infected was reduced. The number of people exposed is decreasing as close contacts for Covid-19 patients are no longer registered in the MySejahtera application. In this context, only a few Covid-19 exposed people with symptoms are considered close contacts. The exposed graph showed a slight increase at day-150 and falls again at day-170.

The number of infected people is higher than the number of exposed people, since the exposed rate also reduce from 10 to 7 people after the endemic. The recovery graph increases on day-100. This is because Malaysians who are awared of the Covid-19 virus are more careful with the outbreak because they know the deadly effects caused by the virus. Therefore, Malaysians began to wear the masks at crowded place and during sickness as a step of precaution. Malaysians also tried to avoid crowded places as recommendation by the goverment.

3.2 The comparison data of spreading Covid-19

Figure 2 showed a higher infected rate compared to Figure 3. This is because with the existence of the new Covid-19 variants such as the Omicron, Delta, and Alpha variants. Not only that, the decreased in infected cases in Figure 3 could be solved with the initiatives taken by the Malaysian Governments to reduce the number of cases. One of the initiatives taken was the introduction and obligation to the public in taking a third vaccine shot which is the booster shot. This also reduced the number of exposed patients, as shown in Figure 3. The exposed graph from Figure 2 and Figure 3 showed significant change in the shape of the graph. The change in the graph is caused by many prevention strategies such as practicing hand hygiene, consistently and correctly wearing a high-quality mask, improving ventilation and keeping your distance.

3.3 Forecast for the epidemic of Covid-19

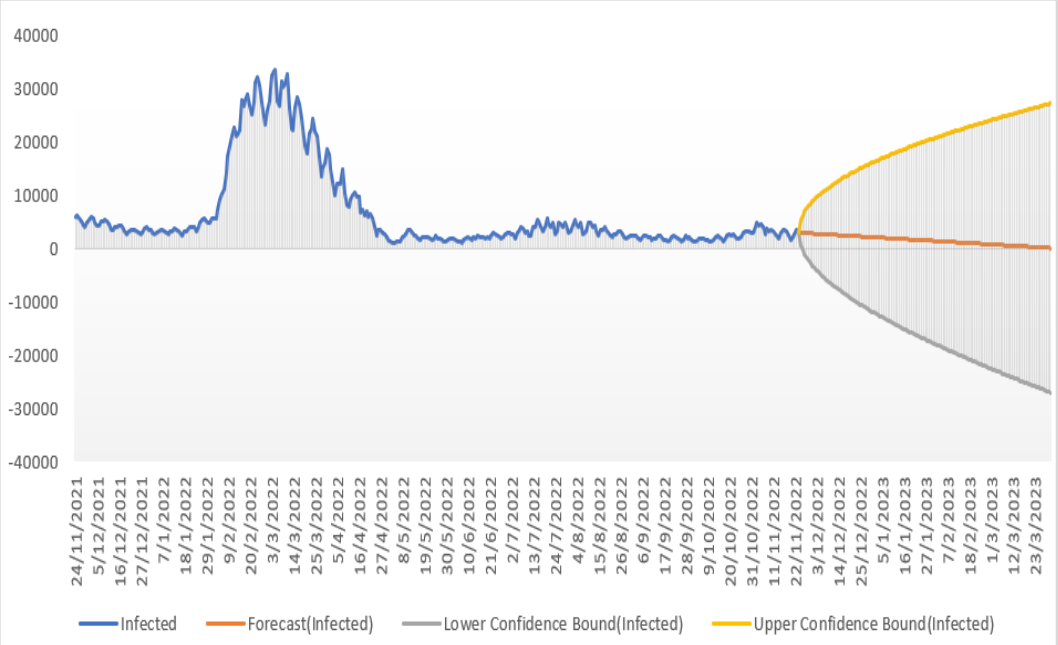

Figure 4: The forecast for infected of Covid-19 between 25 November 2022 until 31 March 2023

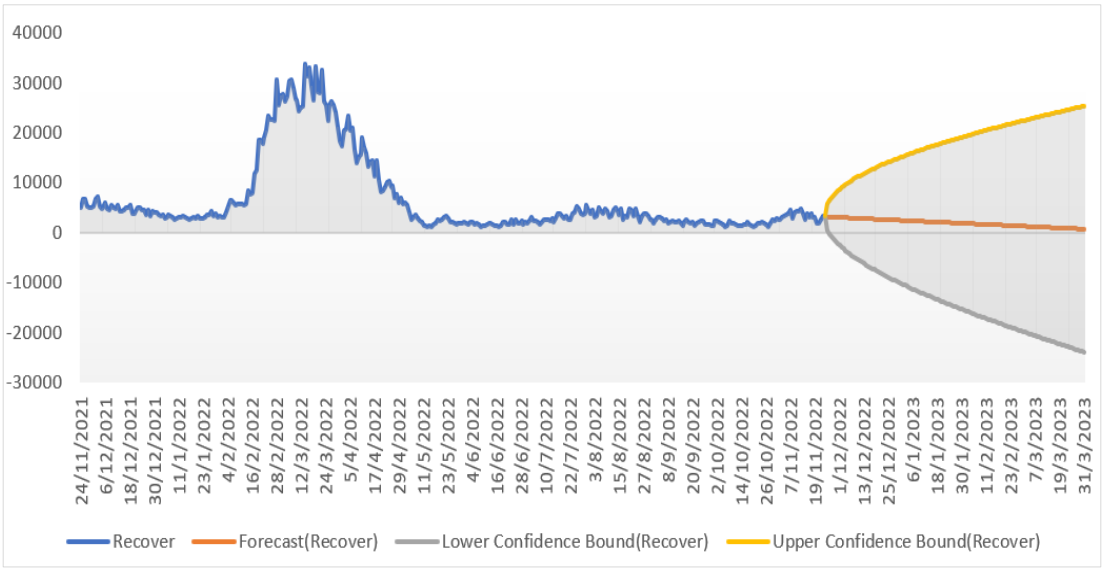

Figure 5: The forecast for recovered of Covid-19 between 25 November 2022 until 31 March 2023

Based on Figure 4 and Figure 5, the number of infected and recovered of Covid-19 is expected to gradually decrease over time. It indicated that if infected number of patients increases, the recovered number of patients increases and vice versa. Due to the decreasing prediction value for infected and recovered, Malaysia is estimated to be able to cope with the Covid-19 virus.

4. Conclusion

In conclusion, the SEIR model has consists with four differential equation which includes for susceptible, exposed, infected, and recovered. In order to analyze the simulation of spreading of Covid-

19 outbreak, the graph of SEIR model was compared graphically which included the number of daily infections, exposed and recovered. The results obtained showed that the graph of infections of Covid-19 disease in year 2021 and 2022 is based on the official statement of health in MOH website. The data was selected from MOH. The comparison of the SEIR model graph was analyzed using Python.

Forecasting of infected cases of Malaysia helps health professionals to be better prepared for the increasing number of patients. In addition, the Forecast can be part of factors to reduce the spread of disease outbreaks [12]. As the Covid-19 pandemic affects both Malaysia's economic growth and labor rates, a recovery from Covid-19 has also been forecasted. Therefore, this study showed that the Malaysian government needed to take precautionary measures and be aware of the situation ahead.

One of the limitations in this research is the value of the R-naught (R_0) and β. The different values of data will generate different forms of the graph. Therefore, it could lead to uncertain conclusions. There are also Malaysians who are not registered as Covid-19 patients, especially after receiving booster, most Malaysians have not registered as Covid-19 patients, they have taken the initiative to isolate themselves at home or work from home.

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