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Experience in successfully applying SIR model in Covid-19 pandemic control policy in Ho Chi Minh City, Vietnam

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Abstract
The outbreak of the novel coronavirus disease (Covid-19) has caused considerable chaos around the world. In Vietnam, with a large population and a lack of specialized medical equipment, the disease quickly spread throughout the country. Ho Chi Minh city, where the population density is the highest in the country and is a place of trade and commerce, here the disease outbreak is strongest and has the highest number of deaths in the country. At first, the Ho Chi Minh city government was also confused in the fight against the epidemic because there was no precedent, but in the end, the government thoroughly applied the SIR model and succeeded in extinguishing the disease. This post is intended to provide an overview of the SIR model and the experience that the Ho Chi Minh City government has applied to replicate this model in future epidemic prevention in developing countries like Vietnam.

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1. Introduction

In early December 2019, an outbreak sickened by coronavirus 2019 (later called is COVID-19), caused by a type of coronavirus 2 (SARS-CoV-2) causes acute respiratory syndrome novelty, happened in the city of Wuhan, Hubei province, China [1]. It is an infectious disease that spread quickly in China and all over the world for the medical world as well as bringing death, economic collapse for all people eliminates the inability of the care system Modern and embarrassing medical of the major govern`ent because there is no precedent.

After many delays, on January 30, 2020, the World Health Organization (WHO) also had to declare the outbreak a global public health emergency (PHEIC - Public Health Emergency of International Concern) to identify and mobilize resources worldwide [2].

It was not until March 11, 2020, that WHO declared the COVID19 outbreak a “pandemic”. Only now are countries allowed to consider closing their borders, imposing travel, or trade restrictions on China.

2. Application of SIR epidemiological model

Since 2020, many mathematical models have been developed to describe the dynamics of the development of COVID-19 [3, 4]. Among them, the infection-recovery (SIR) model is considered as a basic mathematical model for disease spread. This model was proposed in 1927 by Kermack and McKendrick [5, 6], and has been used as a basic model for plague [7, 8, 9, 10, 11].

In November 2002, severe acute respiratory syndrome (SARS) is a severe form of pneumonia that first appeared in China and quickly spread to 29 countries around the world within just a few months. Improved SIR to simulate and predict the spread of this pandemic [12, 13].

The deadliest Ebola virus disease (EVD) outbreak since 1976, which occurred in West Africa in 2014, has wiped out a large portion of the population. In 2020 Aqsa Nazir and colleagues developed the SIR to be able to predict the spread and control of

Ebola disease. In 2015, there was an outbreak of Middle East respiratory syndrome (MERS) in Korea. This is the second major MERS outbreak. As a result of this outbreak, 186 infections were reported, and 36 patients died. At least 16,693 people are isolated with suspicious symptoms. Tuen Wai Ng. and colleagues also used the SIR model to predict the outbreak of this disease.

3. SIR model

Introduced in 1927, the SIR (Susceptible - Infected - Recovered) model [5, 6]. Kermack and McKendrick is a simple mathematical model that describes the evolution of disease and the relationship between the uninfected and the uninfected. Sick (Susceptible) - the sick (Infected) and the recovered (Recovered).

Fig 1: SIR model

The SIR model is a closed system with the following conditions

- There is no migration as well as birth and death.
- The total number of people in the model is one constant.
- Everyone is equally susceptible to infection.
- People who recover from illness or die from illness are considered cured.

The SIR includes the following groups of people

Susceptible: The group of people who are susceptible to infection, convention is that everyone in the community is susceptible to except those who are infected and people recovering from illness.
Infected: The group of people who are suffering from infection.
Recovered: The group of people who have recovered disease includes those who die from disease pandemic. When this group of people is cured have immunity and not get caught again sick.
SIR describes the correlation and change in the number between groups over time based on the system of ordinary differential equations (ODE) is as follows:

$$\frac{dS}{dt} = -\beta IS$$

$$\frac{dI}{dt} = \beta IS - \gamma I$$

$$\frac{dS}{dt} = -\beta IS$$

$$\frac{dR}{dt} = \gamma I$$

There are two important parameters that are
β : Infection rate of a sick person in one day.
γ : Recovery rate of a patient in one day.
Let D be the average number of days a patient recovers then:

$$\gamma = \frac{1}{D}$$

We have: $R_0 = \frac{\beta}{\gamma}$

In epidemiology, R_0 is called the basic reproduction number.
If $R_0 > 1$: The disease will break out and pandemic (epidemic) can happen.
If $R_0 < 1$: The infected person will recover faster than the number of infections and at some points will end the epidemic.

Solving the above differential equations can use RungeKutta RK numerical analysis method to discretize continuous equations or can use machine learning algorithms to optimize curve parameters.

4. SIR model Graph

SIR graph (Figure 2) with initialization values

- $S_0 = 0.99$
- $I_0 = 0.01$
- $R_0 = 0.0$
- $\beta = 0.26$
- $\gamma = 0.1$

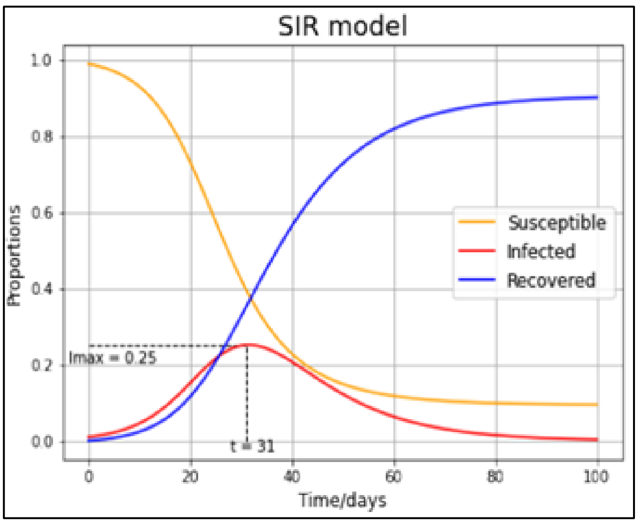

Fig 2: SIR model Graph

5. SIR for Covid-19

Since the Covid-19 pandemic happened, there have been many authors use the model SIR model simulate, optimize the coefficients β, γ for the data of Arab, Alge, Monaco.

Actual data representation of infected people disease of the United Arab Emirates compared to the curve of infected people disease according to the SIR Arab model (Figure 3).

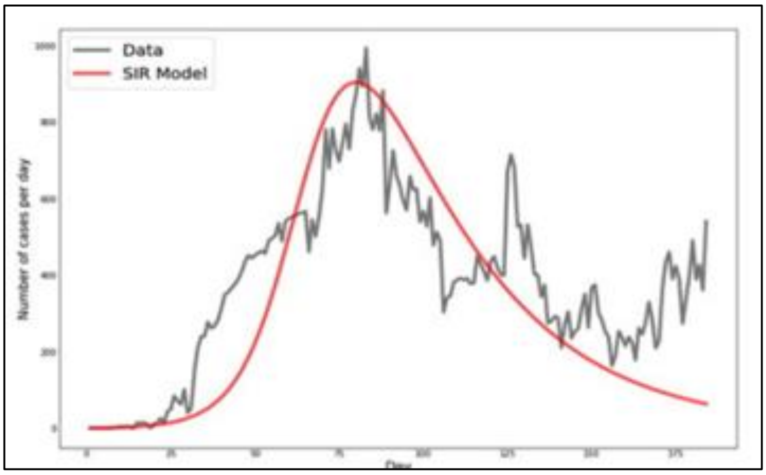

Fig 3: Infected

Simulate recovery data The United Arab Emirates vs tissue line representing infected people SIR Arab figure, (Figure 4).

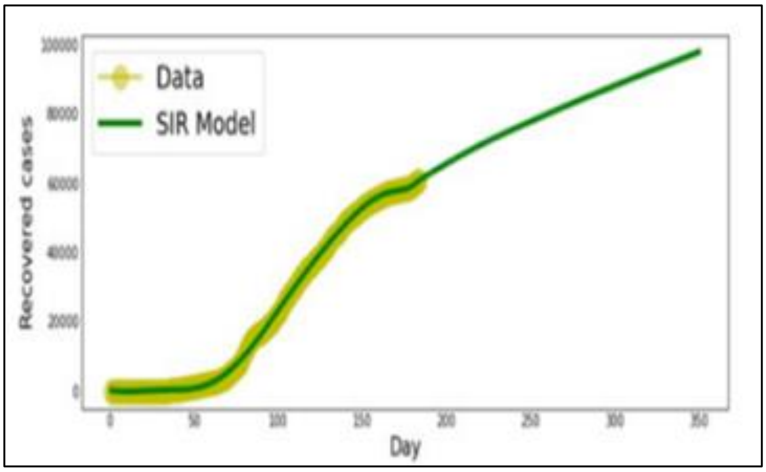

Fig 4: Recovered

The peak of the Principality of Monaco around March 28, 2020, compare data Realistic and SIR Monaco curves, (Figure 5).

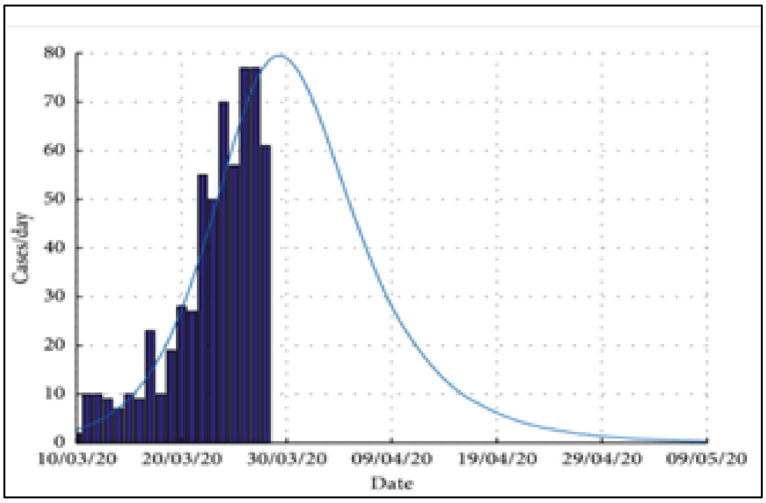

Fig 5: Recovered

6. Covid-19 pandemic control policy in Ho Chi Minh City, Vietnam

Based on the characteristics of the SIR model as a closed model, the Ho Chi Minh City government first needs to have a policy that is harsh but meets the model's criteria:

- Strengthen communication and raise people's awareness of the risks of the disease.
- Use the military to lock blankets the doors to the city.
- Inside the city, the army and militia were used to strictly isolate epidemic areas.
- Implement measures to prevent and control the epidemic at business establishments, schools, hospitals.

These policies have made an important contribution to controlling and preventing the spread of the disease, while helping people stabilize their lives and economy.

In parallel with the above measures, the government also used all medical resources in society, built field hospitals to focus and treat people in a closed loop like the SIR model:

- Limit gatherings of people.
- Closing non-essential businesses.
- People are asked to stay at home and only go out when necessary.
- Practice social distancing.
- Measure body temperature for people entering and leaving.
- Require people to wear masks.
- Arrange hand sanitizer.
- Regular cleaning and disinfection.
- Cash support.
- Support food, food.
- Medical assistance.
- Support vocational training.

7. Lessons learned against Covid-19 in Ho Chi Minh City

We collect information by manual selection from the website of the Vietnamese Ministry of Health [14] and the covid-19 portal of Ho Chi Minh City [15].

1. Ho Chi Minh City directed centrally, mobilized the whole political system and coordinated closely and effectively between departments and agencies and districts, Thu Duc City in a synchronous manner. Effectively implement the strategy "each ward, commune, town is a fortress; Every citizen is a soldier".
2. Building an epidemic surveillance and warning system, developing situations and rehearsal scenarios corresponding to each epidemic level is very necessary and is of decisive significance for the initiative in responding to the epidemic. Timely detect areas at risk of moving to a higher level of epidemic to proactively take measures to intervene. Flexible combination between PCR technique and antigen rapid test to quickly suppress the epidemic.
3. Mobilize all resources in society for epidemic prevention and control. Each district must have a plan for proactive epidemic prevention and control, mobilizing local human resources and effectively using human resources for aid. The city is ready to support and provide human resources to fight the epidemic when districts face difficulties.
4. Promote the effective coordination of the army, police, and health sector in supporting localities from the very beginning. Organize strict isolation, care, and treatment at home, in field hospitals for F0.
5. Vaccines are a long-term and leading strategy in disease prevention and control. Prioritize vaccination for high-risk subjects (pregnant women, people over 50 years old, with underlying diseases, obesity...) and frontline forces in disease prevention and control.

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