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Pediatric and geriatric immunity network mobile computational model for COVID-19

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Abstract

Purpose – The computational model proposed in this work uses the data's of COVID-19 cases in India. From the analysis, it can be observed that the proposed immunity model decides the recovery rate of COVID –19 patients; moreover, the recovery rate does not depend on the age of the patients. These analytic models can be used by public health professionals, hospital administrators and epidemiologists for strategic decision-making to enhance health requirements based on various demographic and social factors of those affected by the pandemic. Mobile-based computational model can be used to compute the travel history of the affected people by accessing the near geographical maps of the path traveled.

Design/methodology/approach – In this paper, the authors developed a pediatric and geriatric person's immunity network-based mobile computational model for COVID-19 patients. As the computational model is hard to analyze mathematically, the authors simplified the computational model as general COVID-19 infected people, the computational immunity model. The model proposed in this work used the data's of COVID-19 cases in India.

Findings – This study proposes a pediatric and geriatric people immunity network model for COVID- 19 patients. For the analysis part, the data's on COVID-19 cases in India was used. In this model, the authors have taken two sets of people (pediatric and geriatric), both are facing common symptoms such as fever, cough and myalgia. From the analysis, it was observed and also proved that the immunity level of patients decides the recovery rate of COVID-19 patients and the age of COVID-19 patients has no significant influence on the recovery rate of the patient.

Originality/value – COVID-19 has created a global health crisis that has had a deep impact on the way we perceive our world and our everyday lives. Not only the rate of contagion and patterns of transmission threatens our sense of agency, but the safety measures put in place to contain the spread of the virus also require social distancing. The novel model in this work focus on the Indian scenario and thereby may help Indian health organizations for future planning and organization. The factors model in this work such as age, immunity level, recovery rate can be used by machine leaning models for predicting other useful outcomes.

Keywords Pediatric, COVID-19, Computational immunity model, Geriatric, Simplified, Patients

Paper type Research paper

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1. Introduction

COVID-19 is a contagious disease because of an extreme acute respiratory syndrome (SARS-COV-2). In December 2019, the disease was first recognized in Wuhan and has now transmitted worldwide, resulting in the present 2019–2020 coronavirus epidemic (World Health Organization, 2020). As per the latest data on May 2, 2020, more than 3.25 million people are infected by the COVID-19 all around the world and nearly close to 239,000 deaths are recorded from different parts of the world. India has been conveniently placed on the list of affected countries with large margins, but recent actions lead to its rise to 35th position, which is a point of concern (mohfw.gov.in, 2020). The mortality rate is controlled, which less than 3% better than the world death rate of approximately 5.5%. However, the transmission trend is slowly heading toward an unsustainable level that can lead to significant loss of lives and development (mygov.in, 2020). Currently, India is being viewed by various nations as a global leader and even WHO recognizes that the world would look at Indian measures to suppress the outbreak (Sharma, 2020). India has systematically followed lockdown since March 22, 2020. It was a 1-day lockdown, followed by a 21-day shutdown after two days. Since then, each operation in India has been authorized by several government departments and almost all domestic and foreign transport has either been prohibited or strictly monitored. India is yet to reach the third phase of the COVID-19 epidemic, the infection of the population by many countries around the world, but there has been a substantial increase in cases. India's lockdown was influenced by two significant events connected to the mass migration of workers from one state to another. This work analyzes the present situation and the impact of various occurrences in India using mathematical model for pediatric and geriatric people by an assumption of a simplified model (SI). This model may be used for the following purposes: to analyze the mechanisms by which diseases spread, to predict the future course of an outbreak, to frame high-level decisions on how to handle or mitigate the situation and finally, to evaluate strategies that are used to control an epidemic.

2. Description of notations

Table 1 shows the variables and descriptions used in this computational model.

Table 2 shows the list of parameters and its relevant descriptions used in this computational model.

3. Model descriptions

3.1 Assumption for pediatric and geriatric people model

In this computational model, as shown in Figure 1, we are dealing with two sets of people, one is pediatric people (age: 1-18 years) and the other set is geriatric people (age: above 60 years). The suspected people are supposed to be diagnosed with the symptom-tests and then may confirm to be a COVID-19 victim. This can be diagnosed through mobile computing technologies by analyzing the travel history of the patients.

3.2 Pediatric people (λ_P) (age: 1-18 years)

- The pediatric people group is divided into five components; they are sustainable pediatric people, exposed pediatric people, infected pediatric people and the immune pediatric people and the recovered pediatric people.
- Suspected pediatric people are denoted by S_P; once they are suspected for COVID-19, they will undergo with basic symptom test. Basic symptoms are fever ($\boldsymbol{\pi}$) and dry cough ($\boldsymbol{\mu}$). This pediatric stage people are assumed as exposed people (E_P).
- After E_P stage, people start to transmit (β) the infection. To conform COVID-19 infection, one more symptom test is there, which is a test of myalgia ($\boldsymbol{\varphi}$).

- Pediatric people are now in immunity (I_P) test stage; in this stage, we will check the pediatric peoples' immunity rate (k). Immunity test plays a vital role in COVID-19 because it decides the recovery rate of the patient.

Variables	Description
S_P	Sustainable pediatric people
E_P	Exposure of starting symptoms for pediatric people
IP	Infected pediatric people
X_P	Immunity of pediatric people
R_P	Recovery of pediatric people
S_G	Sustainable geriatric people
E_G	Exposure of starting symptoms for geriatric people
I_G	Infected geriatric people
X_G	Immunity of geriatric people
R_G	Recovery of geriatric people

Table 1. List of variables and description

Parameter	Description
α	People with starting symptoms
β	Transmission rate
k	Efficiency of immunity
ρ	Rate of recovery
π	Test for fever
μ	Test for cough
φ	Test for myalgia
Y	Comparison of X_P and X_G
Z	Comparison of R_P and R_G

Table 2. List of parameters and description

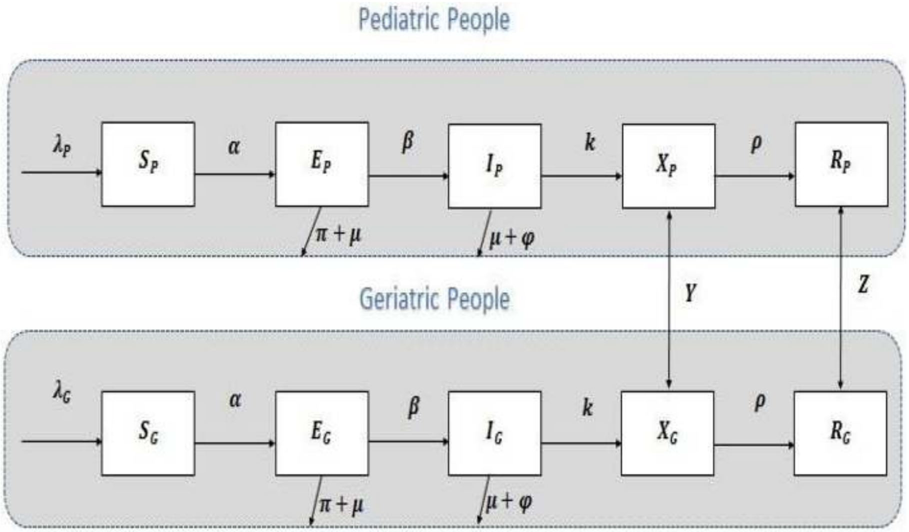

Figure 1. Pediatric and geriatric people model

- Immunity (I_P) and recovery (R_P) stages are interrelated because if immunity is more for a patient, then their recovery possibility is also high. In the recovery stage, we will check the rate of recovery (ρ).

3.3 Geriatric people (λ_G) (age: above 60 years)

- The geriatric people group is divided into five components; they are sustainable geriatric people, exposed geriatric people, infected geriatric people, the immune geriatric people and recovered geriatric people.
- Suspected geriatric people are denoted by S_G; once they are suspected for COVID-19, they will undergo with basic symptom test. Primary symptoms are fever (π) and dry cough (μ). This stage geriatric people are assumed as exposed people exposure stage (E_G).
- After E_P stage, people start to transmit (β) the infection. To conform to COVID-19 infection, one more symptom test is there, which is the test of myalgia (φ).
- Geriatric people are now in immunity (I_G) test stage. In this stage, we will check the geriatric peoples' immunity rate (k). Immunity test plays an essential role in COVID-19 because it decides the recovery rate of the patient.
- Immunity (I_G) test and recovery (R_G) stages are interrelated because if immunity is more for a patient, then their recovery possibility is also more. In the recovery stage, we will check the rate of recovery (ρ).

Among these two sets of people, we are comparing the immunity stage (Y) and the recovery stage (Z). From this analysis, we observe that the recovery rate of COVID-19 is highly dependent on the immunity of the people, not on patient age. Mobile-based computational techniques help in finding these kinds of cases.

4. Modeling process

The following equations are derived using model diagram and assumptions:

$$\frac{dS_P}{dt} = \lambda_P - \alpha_P$$
$$\frac{dE_P}{dt} = \alpha_P - (\pi + \mu) - \beta_P$$
$$\frac{dI_P}{dt} = \beta_P - (\mu + \varphi) - k_P$$
$$\frac{dX_P}{dt} = k_P - Y - \rho_P$$
$$\frac{dR_P}{dt} = \rho_P - Z$$
$$\frac{dS_G}{dt} = \lambda_G - \alpha_G$$
$$\frac{dE_G}{dt} = \alpha_G - (\pi + \mu) - \beta_G$$
$$\frac{dI_G}{dt} = \beta_G - (\mu + \varphi) - k_G$$
$$\frac{dX_G}{dt} = k_G - Y - \rho_G$$
$$\frac{dR_G}{dt} = \rho_G - Z$$

such that:

$$N = S_P + E_P + I_P + X_P + R_P + S_G + E_G + I_G + X_G + R_G$$

4.1 Assumption for simplified model

The people are divided into five components; they are sustainable people, exposed people, infected people, immune people and recovered people.

Suspected people are denoted by S; once they are suspected for COVID-19, they will undergo the basic symptom test. Primary symptoms are fever (π) and dry cough (μ). This stage people are assumed as exposed people (E).

After the E stage, people start to transmit (β) the infection. To conform to COVID-19 infection, one more symptom test is there, which is the test of myalgia (φ).

Geriatric people are now in the immunity (***I***) test stage; in this stage, we will check the geriatric peoples' immunity rate (k). Immunity test plays a vital role in COVID-19 because it decides the recovery rate of the patient.

Immunity (***I***) test and recovery (R) stages are interrelated, because if immunity is more for a patient, then their recovery possibility is also more. In the recovery stage, we will check the rate of recovery (ρ).

After completing the recovery stage, compare I and R, to define the recovery rate is depends on the immunity rate.

4.2 Simplification of the general COVID-19 infected people immunity model

To simplify, we are normalizing the model and changing the SI into proportion. Now, we consider the model as typical for both the set of people (pediatric and geriatric).

$$\frac{dS}{dt} = \lambda - \alpha S \tag{1}$$

$$\frac{dE}{dt} = \alpha S - (\pi + \mu) - \beta E \tag{2}$$

$$\frac{dI}{dt} = \beta E - (\mu + \varphi) - kI \tag{3}$$

$$\frac{dX}{dt} = kI - \rho X \tag{4}$$

$$\frac{dR}{dt} = \rho X - R \tag{5}$$

Proportion for the SI equation:

$$\begin{aligned} \frac{dN}{dt} &= \frac{dS}{dt} + \frac{dE}{dt} + \frac{dI}{dt} + \frac{dX}{dt} + \frac{dR}{dt} \\ \frac{dN}{dt} &= \lambda - (\pi + \mu) - (\mu + \varphi) - \mathrm{R} \end{aligned} \tag{6}$$

$$\text{Let, s} = \frac{S}{N},\ \text{e} = \frac{E}{N},\ \text{i} = \frac{I}{N},\ \text{r} = \frac{R}{N},\ \text{x} = \frac{X}{N} \tag{7}$$

Normalized systems are given as:

$$\frac{ds}{dt} = \frac{1}{N}\left(\frac{ds}{dt} - s\frac{dN}{dt}\right)$$

Substituting equations (1) and (6) using equation (7):

$$= \frac{\lambda(1-s)}{N} - \alpha s + (\pi + \mu)\text{s} + (\mu + \varphi)s + \text{rs}$$

Similarly:

$$\frac{de}{dt} = \frac{1}{N}\left(\frac{de}{dt} - e\frac{dN}{dt}\right)$$

Substituting equation (2) and (6) using equation (7):

$$= \alpha e - (\pi + \mu) - \beta e - \frac{e\lambda}{N} + (\pi + \mu)\text{e} + (\mu + \varphi)\, e + \text{re}$$

Next, we have:

$$\frac{di}{dt} = \frac{1}{N}\left(\frac{di}{dt} - i\frac{dN}{dt}\right)$$

Substituting equations (3) and (6) using equation (7):

$$= \beta e - (\mu + \varphi) - ki - \frac{i\lambda}{N} + (\pi + \mu)\text{I} + (\mu + \varphi)i + \text{ri}$$

and

$$\frac{dx}{dt} = \frac{1}{N}\left(\frac{dx}{dt} - x\frac{dN}{dt}\right)$$

Substituting equations (4) and (6) using equation (7):

$$= ki - \rho x - \frac{x\lambda}{N} + (\pi + \mu)\text{x} + (\mu + \varphi)x + \text{rx}$$

and finally:

$$\frac{dr}{dt} = \frac{1}{N}\left(\frac{dr}{dt} - r\frac{dN}{dt}\right)$$

Substituting equations (5) and (6) using equation (7):

$$= \rho x - r - \frac{r\lambda}{N} + (\pi + \mu)\mathrm{x} + (\mu + \varphi)x + \mathrm{rx}$$

However:

$$\mathrm{s + e + i + x + r = 1}$$

5. Case analysis: description and validation for COVID-19 scenario in India

According to the WHO (2020), the total cases of COVID-19 in India stand nearly to 40,000 infected cases and the current total death is 1,304. The impact of COVID-19 in India is reported to be less than the worst affected countries (mygov.in, 2020).

Figure 2 explains COVID-19 infection cases in India from February 18 to April 28, which were nearly around 40,000. Figure 3 illustrates the date wise analysis and the number of infected people present in India because of COVID-19.

Figure 4 shows comparison between newly infected and newly recovered cases present in India. Figure 5 determines the percentage rate of death and the rate of recovery in India.

Table 3 shows the number of COVID-19 cases in India grouped by age. As per the report on April 27, 2020, most of the COVID-19 affected individuals were between 21 and 40 years in India. In the age group between 31 and 40 years, around 537 cases were mostly infected. Compared to other nations, this proportion is significantly low. Moreover, India has a

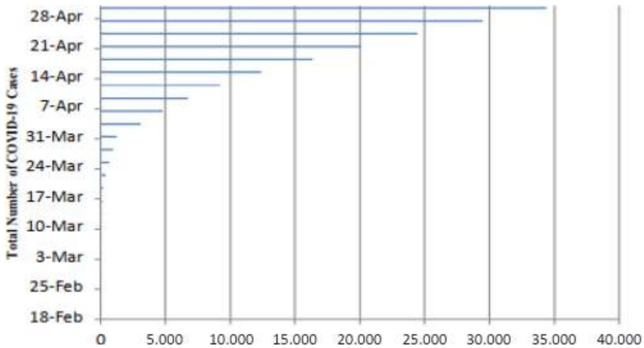

Figure 2. Total occurrence cases in India

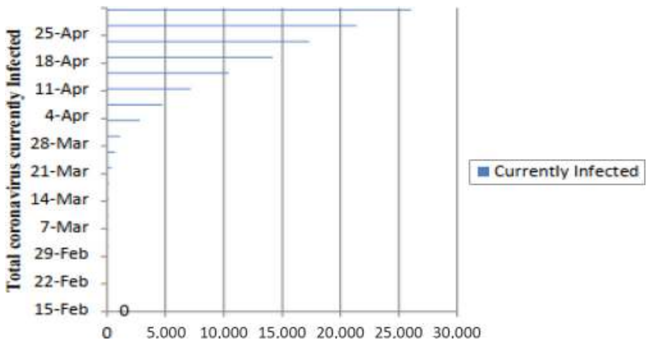

Figure 3. Number of infected people

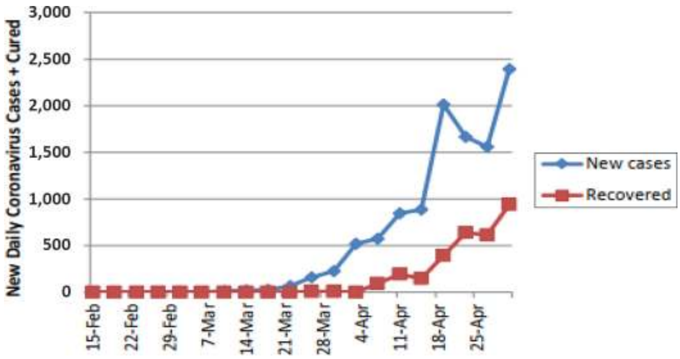

Figure 4. Newly infected vs newly recovered in India

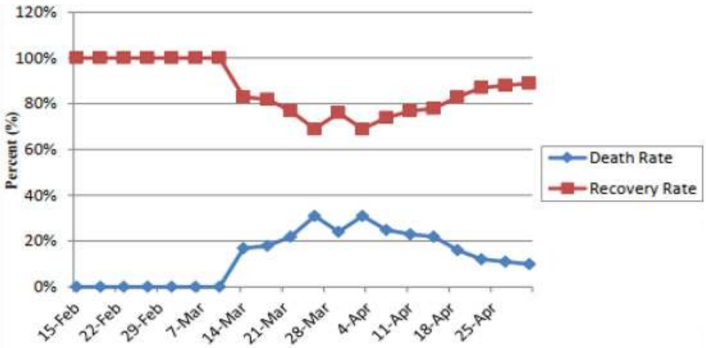

Figure 5. Outcome of cases (recovery or death) in India

Table 3. Number of the COVID-19 cases in India (age group-wise)

Age	No. of cases	Affected (%)
0-10	98	2.5
11-20	228	5.0
21-30	514	20.8
31-40	537	17.4
41-50	383	13.3
51-60	306	13.2
61-70	204	13.2
71-80	62	4.3
81-90	10	1.1
91-100	3	0.1

smaller demographic trend compared to other Western nations that directly affected the percentage of COVID-19 cases. More than 73% of the infected are male and 27% of the infected are female, as shown in Figure 6.

The characteristic of the coronavirus, 2019-nCoV that causes COVID-19 is closer to pandemic flu H1N1 that persisted as seasonal flu than SARS that was eliminated quickly. The case fatality rate in India needs to be monitored as well. If the standard of care is not as good

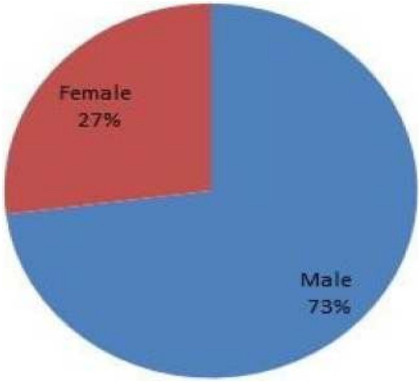

Figure 6.
Gender distribution of COVID-19 patients in India

as in other countries, our case fatality rate will be higher, as experienced during the H1N1 outbreak (John, 2020). Most district hospitals, however, do not yet have an influenza diagnostic capacity. If the coronavirus infection reaches an unexpected place, a cluster may develop before the diagnosis is established. Then it will be difficult or even impossible to trace and track all persons in contact with every infected individual. Hence, universal health care and public health with readily reachable laboratories are essential. This model can be used by hospital administrators in the allocation of medical resources to patients, such as ventilators and diagnostic devices, based on the actual factors that affect the COVID-19 infection.

5.1 Mobile computational technology helps COVID-19

Computational technology cannot prevent the onset of the pandemics; however, it can help to prevent the spread of COVID-19. For example, color-coded QR codes can be used to track the coronavirus spread with the help of mobiles. Alibaba Group and Tencent's holidays, in collaboration with China, has launched the application for tracking the spread of coronavirus called "Alipay Health Code" (thequint.com, 2020). It assigns a colored QR code in the form of red, yellow and green. It is used to decide whether a person needs to be quarantined or safe to step out into the public places, offices and apartments. Similarly, the developers of "WeChat" have introduced an application for detecting and tracking the close contacts. It uses the QR code-based tracking mechanism to identify someone in contact with coronavirus victims. The computational systems can be used to classify the people into categories. This compulsory application uses the data from transport agencies and medical centers to find the carriers of the coronavirus (blog.signzy.com, 2020).

Also, mobile-based computational models can be used to find and track the temperature of their own, nearby people and geographical locations. Health-care suggestions and guidelines from medical practitioners can be obtained through mobile technologies. The mobile-based computational devices are equipped with GPS, wireless and bluetooth, and it can be used to collect and store the data in the database based on predetermined periodical intervals of time. Later, the collected data can be used for analysis and contact tracing on demand. The nearby devices recently contacted can also be effectively tracked. Wearable devices such as sensors and IoT devices can be used to interact and communicate with mobile devices for gathering the data for analysis. It is concluded that the mobile-based computational systems play a vital role in preventing the COVID-19 and supports the public to protect themselves.

6. Conclusion

This study proposes a pediatric and geriatric people immunity network model for COVID-19 patients. For the analysis part, the data's on COVID-19 cases in India was used. In our model, we have taken two sets of people (pediatric and geriatric), both facing common symptoms such as fever, cough and myalgia. From the analysis, it was observed and also proved that the immunity level of patients decides the recovery rate of COVID −19 patients and the age of COVID-19 has no significant influence on the recovery rate of the patient. The scope of this work can be further extended by scaling up the data used for analysis. IoT with mobile devices and this type of computational model can be used to send the collected data such as temperatures, location in the cloud with relevant applications and medical experts for analysis. A massive volume of data can be collected in a lesser duration, which helps for quick decision-making. It reduces the burden of health-care professionals, which helps in better care and treatment. The models may need machine-learning algorithms and similar computing approaches to integrate the increasing volume of data being generated; thereby, more inferences and knowledge about the pandemic can be provided to epidemiologists to handle different scenarios during critical times of a pandemic.

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