ANNQUEST JULY 2020
ISSN:2321-3043

www.stannsannquest.com

A MATHEMATICAL APPROACH TOWARDS THE ONSET OF PANDEMIC COVID-19 AND PREVENTIVE MEASURES

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Abstract:

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which started in Wuhan city, China in the month of December 2019, spreading globally resulting in an ongoing pandemic. As of 15 May 2020, more than 4.44 million cases have been reported across 188 countries with death rates trolling beyond 302, 000.The first COVID-19 case in India was reported on 30 January 2020, originated from China.As of 15 May 2020, the Ministry of Health and Family Welfare have confirmed a total of 81,970 cases, 27,920 recoveries (including 1 migration) and 2,649 deaths in the country. The infection rate of COVID-19 in India is reported to be 1.7, significantly lower than in the worst affected countries which is due to the immediate precautions taken up by the Government of India with a strict lock down procedure followed across the country, Janata Curfew, seizing the National and International commute ways at the cost of risking the economic growth which is a massive setback in protecting human lives. Based on the transmission mechanism of disease among the population and the implementation of prevention and control measures, a mathematical model using mathematical formulations have been put forth in this research article.

Keywords: Covid-19, Virus, Pandemic, Mathematical Model

Introduction:

With the outbreak of COVID-19 pandemic in China and people falling dead on the streets of major cities, was a devastating situation ever seen in the history of mankind(5,6). Global connect to different countries with modern technology and high-end equipment's have made the huge world into a minuscule. Mankind has indeed evolved with latest gadgets to such an enormous extent where life has been made easy in several aspects. Luxury, comfort, money is the driving force in contemporary times where, emotions, ethics and cultural values are being given least priority. The social connect between different countries is a matter of few seconds from booking the flight tickets online to travelling in the miniature world, so is the spread of deadly pandemic. The virus which took lives of many in China slowly spread its wings to every nook and corner of the world where India was not left behind in recording its first ever case in January 2020. Since then, many unexplained cases of pneumonia with cough, fatigue, and high fever among the effected as the main symptoms were recorded. Observing the on spread of disease, the government of India under the Epidemic Diseases Act, 1897 has taken a quick action and major initiative of lock down, Janata curfew in every part of the country to save human life.On 22 March 2020, India observed a 14-hour voluntary

public curfew at the instance of the prime minister Narendra Modi. The government followed it up with lockdowns in 75 districts where COVID-19 cases had occurred as well as all major cities. Further, on 24 March, the prime minister ordered a nationwide lockdown for 21 days, affecting the entire 1.3 billion population of India. On 14 April, the prime minister extended the ongoing nationwide lockdown till 3 May. India was praised by World Health Organization(4) for its tremendous ability to deal with the covid-19 outbreak though being the second largest populated country in the world which has been possible due to a great deal of immune system among Indians in comparison to other countries for prior generations being close to mother earth in agriculture being their major occupation.

Objective of the Research:

Covid-19 pandemic outbreak has been a major setback to Indian economy, has hindered the growth in every aspect of social and economic life, due to massive lock down in the last two months. The objective of the research carried in this article provides us with the data of people affected, quarantined and cured from the time of disease outbreak which is presented using a mathematical model used to calculate the above data useful for further identifications. The spread of virus has been fatal to mankind consuming lives of many. With no medication and vaccination available, prevention has always been better than cure. Preventive measures like social distancing, hygiene is suggested to protect oneself from the deadly virus.

Mathematical Model:

The Covid-19 being a novel pandemic which was discovered recently in December 2019, data on the outbreak is yet insufficient, and medical trials are in very difficult and exploratory stage. So far, epidemic data have been difficult to apply directly to existing mathematical models, and questions need to be addressed as to how effective the existing emergency response has been and how to invest medical resources more scientifically in the future and so on. Based on this, the article aims to study the bridge created in this part. Based on the data provided by the ministry of health and family welfare the mathematical model proposed in this article finds a propagation rule of the Covid-19, predicts the epidemic situation, and then provides an effective control and preventive methods.

Table 1: Classification and Definition of Population under transmission of new Coronavirus

Classes	Explanation
S(t)	People who may be infected by the virus
E(t)	Infected but without any symptoms shown
I(t)	Highly Infectious but not yet Quarantined
Q(t)	Diagnosed and Quarantined
D(t)	Suspected Cases of Victims
R(t)	People who are cured after infection

SEIQDR-Based Model for Estimation:

The above model depicted in the table is SEIQDR model(1) used to estimate the mathematical model of people effected, virus being transmitted, number of people quarantined and cured. Since the incubation period of the Covid-19 is from 2

to 14 days, E(t) denotes the infected but undetected people among the natural environment of the susceptible population S(t) with the identification of first effected case. Certain people who have been infected by the virus but needs to go through certain incubation period before suspected symptoms be detected Q(t). Confirmed cases of victims is D(t) but there are other set of population who are infected and sick, but not isolated are highly fatal to the other group of population. After a period of quarantine treatment, these two groups will be discharged from the hospital R(t) or might face death due to the disease. The diagnosed patients will become healed after a certain period of isolation and treatment.

- Let γ denote the ratio of people who are cured per day to those who are diagnosed.
- Let δ denote the fatality rate of the new pneumonia, reflecting the lethal intensity of Covid-19.
- The rate at which suspected patients are converted into confirmed cases represents a measure of quarantine intensity due to constant changes in medical procedures represented by d_{qd}.
- Highly infectious people in the free atmosphere will be transferred to confirmed cases at the rate of d_{id}.
- The rate at which people move out due to lack of timely treatment is denoted by δ_1.
- The incidence rate of the Susceptible population S(t) has been set to f(t) which can reflect the infection degree of Covid-19.
- The susceptible population in the free atmosphere will become latent after being effected by the virus and gradually develop after the incubation period.
- Let ε denote the proportion of latent persons who were converted to free infection.
- The proportion identified as suspected cases is referred to as $d_{eq.}$
- After the diagnosis, few of suspected cases were confirmed while others not detected and returned to susceptible population were with the ratio $d_{qs.}$
- The susceptible population also been converted to suspected cases at the rate of $d_{qs.}$

The SEDQIR model established based on the dynamic transmission of infectious diseases is as follows:

$$\frac{dS}{dt} = d_{qs}Q(t) - f(t) - d_{sq}S(t)$$

$$\frac{dE}{dt} = f(t) - \varepsilon E(t) - d_{eq} - E(t)$$

$$\frac{dD}{dt} = d_{qd}Q(t) + d_{id}I(t) - (\gamma+\delta)D(t)$$

$$\frac{dQ}{dt} = d_{eq}E(t) + d_{sq}S(t) - d_{qs}Q(t) - d_{qd}Q(t)$$

$$\frac{dI}{dt} = \varepsilon E(t) - d_{id}I(t) - \delta I(t)$$

$$\frac{dR}{dt} = \gamma D(t)$$

To have a deeper Covid-19 transmission rule, we perform a detailed analysis of few parameters to transform the degree of infection into a more conductive data expression in susceptible population f(t),

the mathematical expression is as follows:

$$f(t) = (\beta_E CE + \beta_I CI)\frac{S}{S+E+I+R} = \frac{\beta_I CS}{S+E+T+R}(kE+I)$$

Where $k = \frac{\beta_\varepsilon}{\beta_I}$

The infection rate coefficients of latent and freely infected people in the susceptible populations is referred to as β_E and β_I. At this stage, the epidemic caused by Covid-19 may still be in the early stages of spreading among the population. We need to fit and estimate the above parameters through the original data published by the ministry of health and family welfare of India. Hence, we will formulate the formula to a certain extent as follows:

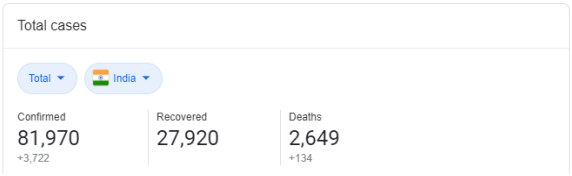
$$f(t) = \beta(t)(kE+I)$$

The infection rate β(t) can be estimated and fitted based on the existing data, and k value reflects the infectivity of the latent person relative to the infected person. Furthermore, according to the definition of incidence, the rate of infection can be expressed by the number of people diagnosed over a period. If the number of people diagnosed on day t is F, the infection rate can be expressed as follows:

$$\beta(t) = \frac{F(t+d_1+d_2)}{\sum_{j=0}^{d_2-1} F(t+j) + k \sum_{j=d_2}^{d_1+d_2-1} F(t+j)}$$

Where d_1 is the average incubation period of Covid-19 and d_2 is the time during which the incubator is isolated after the incubation period. Based on the available data, the infectious rate can be calculated numerically.(2,3)

Data of Covid-19 cases in India till date (Ministry of Health and Family welfare):



Preventive Measures suggested:

As per the saying, prevention is better than cure, it is our due responsibility to safeguard the lives of people around us. Hence a few measures to be followed are put forth(4).

- Use soap and water or an alcohol-based hand sanitizer to clean your hands regularly.
- Maintain a safe distance from anyone who is coughing or sneezing.
- Do not touch your eyes, nose, or mouth.
- Cover your nose and mouth with your bent elbow or a tissue when you cough or sneeze.
- Stay home if you feel unwell.
- If you have a fever, cough and difficulty in breathing seek medical aid.

- Follow the directions of your local health authority.
- Avoid unwanted visits.
- Unless and until required do not step out of your house.
- Maintain Physical distancing.

Conclusions:

The following conclusions have been suggested through this article:

- Since January 2020 Covid-19 pandemic has stuck India with a massive force that today all of us are living with fear. It is essential and as sensible citizens of our country we need to protect each one's lives. Hence a healthy, clean, hygienic, and safe lifestyle is a must in contemporary times.
- The SEIQDR mathematical model proposed is useful to calculate the number of people effected by the virus, number under diagnosis and number of people out of danger which is useful with the data available.
- As the Virus is taking the lives of many it is important to follow the preventive measures suggested above.
- The major purpose of going for a mathematical approach towards the analysis of data obtained from Covid-19 cases is, the segregation of people infected, under quarantine and recovered becomes much easier to understand and interpret with the model put forth.
- The future perspective of the research article would be to extend the mathematical model not only for the analysis and segregation of the data collected but also the aftereffects of the virus when things settle down in the masses. The atmospheric, social, economic, well being of the man kind would be put forth.

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