INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 2 - V7I2-1213)
Available online at: https://www.ijariit.com

A model to predict Covid-19 epidemics with application to India, China and Pakistan

K. Ajithkumar
ajithab1202@gmail.com
Sacred Heart College, Tirupattur, Tamil Nadu

V. Mahendran
mahendravenkatesan@gmail.com
Sacred Heart College, Tirupattur, Tamil Nadu

ABSTRACT

In this work, our group builds up a differential conditions model of Coronavirus pandemics. We will probably anticipate forward in time the future number of cases from early detailed case information in areas all through the world. Our model consolidates the accompanying significant components of Coronavirus pandemics: (1) the quantity of asymptomatic irresistible people (with exceptionally gentle or no indications), (2) the quantity of suggestive announced irresistible people (with extreme side effects) and (3) the quantity of indicative unreported irresistible people (with less serious manifestations). We apply our model to Coronavirus plagues in India, china and Pakistan.

Keywords: *COVID-19 Epidemic, Reported and Unreported Cases, Isolation, Quarantine, Public Closings*

1. MODEL

In previous works [1], [2], [3], our team developed differential equations models of COVID-19 epidemics. Our goal was to predict forward in time the future number of cases from early reported case data in regions throughout the world. Our models incorporated the following important elements of COVID-19 epidemics: (1) the number of asymptomatic infectious individuals (with very mild or no symptoms), (2) the number of symptomatic reported infectious individuals (with severe symptoms) and (3) the number of symptomatic unreported infectious individuals (with less severe symptoms). Our models decomposed COVID-19 epidemics into three phases:

Phase I: the number of cumulative reported cases increases linearly day by day;
Phase II: the number of cumulative reported cases increases exponentially day by day;
Phase III: the number of daily reported cases decreases day by day.

The transitions between phases are generally difficult to determine, but can be estimated from reported cases data, as time progresses. Our model here consists of the following differential equations and initial conditions:

$$S'(t) = -T(t)S(t)[I(T) + U(T)], S(t_0) = S_0$$

$$E'(t) = -T(t)S(t)[I(T) + U(T)] - \alpha E(t), E(t_0) = E_0$$

$$I'(t) = \alpha E(t) - \vartheta I(t), I(t_0) = I_0$$

$$R'(t) = \vartheta_2 I(t) - \mu R(t), R(t_0) = R_0$$

$$U'(t) = \vartheta_2 I(t) - \mu U(t), U(t_0) = U_0$$

Here $t \geq t_0$ is time in days, U_0 is the starting date of the pestilence, S(t) is the quantity of people powerless to contamination at time t, E(t) is the quantity of asymptomatic noninfectious (uncovered or idle tainted) people at time t, I(t) is the quantity of asymptomatic however irresistible people at time t, R(t) is the quantity of announced suggestive irresistible people at time t, and U(t) is the quantity of unreported indicative irresistible people at time t.

The time-subordinate transmission rate boundary is (t). Recently contaminated noninfectious asymptomatic people E (t) are brooding a normal time of 1/α days. Asymptomatic irresistible people I (t) are irresistible for a normal time of 1/ν Here $t \geq t_0$ is time in days, t_0 is the starting date of the scourge, S(t) is the quantity of people helpless to contamination at time t, E(t) is the quantity of asymptomatic noninfectious (uncovered or idle tainted) people at time t, I(t) is the quantity of asymptomatic however irresistible people at time t, R(t) is the quantity of revealed indicative irresistible people at time t, and U(t) is the quantity of unreported suggestive irresistible people at time t.

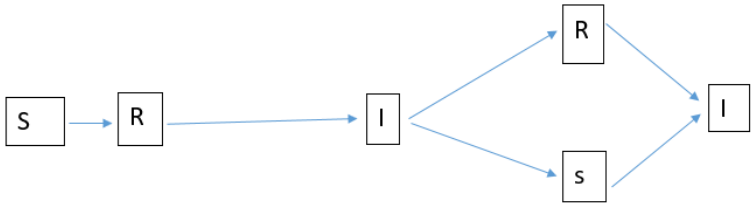
The time-subordinate transmission rate limit is (t). As of late debased noninfectious asymptomatic individuals E (t) are agonizing a typical season of 1/α days. Asymptomatic powerful individuals I (t) are overpowering for a typical season of 1/ν days. Uncovered interesting overpowering individuals R (t) are overwhelming for an ordinary season of 1/η days, as are unreported characteristic powerful individuals U (t). We acknowledge that reported characteristic powerful individuals R (t) are represented and isolated speedily, and cause no further sicknesses. The asymptomatic individuals I (t) can similarly be viewed as having a low level intriguing state. All defilements are acquired from conceivably I (t) or U (t) compelling individuals. The division f of asymptomatic powerful become definite characteristic overwhelming, and the section 1 − f become unreported intriguing overpowering. The rate at which asymptomatic compelling become days. Itemized demonstrative powerful individuals R (t) are overwhelming for a typical season of 1/η days, as are unreported interesting overpowering individuals U (t). We acknowledge that uncovered interesting overpowering individuals R (t) are represented and separated immediately, and cause no further defilements. The asymptomatic individuals I (t) can in like manner be viewed as having a low level intriguing state. All defilements are acquired from it is conceivable that I (t) or U (t) overpowering individuals. The part f of asymptomatic compelling become uncovered interesting overpowering, and the division 1 − f become unreported demonstrative overwhelming. The rate at which asymptomatic overpowering become announced suggestive is $\vartheta_1 = f\vartheta$, the rate at which asymptomatic irresistible become unreported indicative is $\vartheta_2 = (1 - f)$, where $\vartheta_1 + \vartheta_2 = \vartheta$.

The cumulative number of reported cases CR (t) at time t is $CR(t) = v_1 \int_{t_0}^{t_1} I(\sigma)d\sigma\,, t \geq t_0$

The cumulative number of unreported cases CU (t) at time t is $CR(t) = v_1 \int_{t_0}^{t_1} I(\sigma)d\sigma\,, t \geq t_0$

The daily number of reported cases DR (t) at time t is obtained from the solution of the equation

$CDR' = v_1 I(t) - DR(t), t \geq t_0 . DR(t_0) = DR_0$



2. PARAMETERS

The part f of all out indicative irresistible cases that are accounted for is obscure, and shifts from one district to another. We accept η = 1/7, which implies that the normal time of irresistibleness of both unreported suggestive irresistible people and detailed indicative irresistible people is 7 days. We expect ν = 1/6, which implies that the normal time of irresistibleness of asymptomatic irresistible people is 6 days. We expect α = 1, which implies that the normal time of uncovered people is 1 day. These qualities can be altered as additional epidemiological data gets known. As of now, they are predictable with acknowledged qualities. A Coronavirus scourge advances from Stage I to Stage II at the time $t_1 > t_0$. Before t_1 the aggregate number of announced cases information increments straightly step by step. After t_1 the total detailed cases information increments dramatically step by step. The estimation of t_1 is assessed from the aggregate revealed cases information in an expected time stretch [t_1 , t_2], as indicated by the recipe:

$$CR(t) = X_1 \exp(X_2 t) - X_3, t_1 \leq t \leq t_2$$

We typically set the value $X_3 = 1$, but allow for other values. The initial value S0 corresponds to the population of the region of the reported case data. The other initial conditions are

$$I_0 = \frac{X_2\, X_3}{f(\,v_1 + v_2)}\,, \quad E_0 = \frac{X_2 + v}{\alpha} I_0, \quad U_0 = \frac{v_2}{X_2 + \eta} I_0.$$

Further, the value of t0 (when R (t_0) = CR (t_0) = 0) for the starting time t0 of the epidemic in the model is given by

$$CR(t) = X_1 \exp(X_2 t) - X_3 = 0 \rightarrow t_0 = \frac{1}{X_2}(In(X_3) - In(X_1))$$

Additionally,

$$CR(t) = X_1 \exp(X_2 t) - X_3, t_1 \leq t \leq t_2$$

$$T_0 = \frac{(X_2 + \alpha)E_0}{S_0(I_0 + U_0)} = \frac{(X_2 + v)(X_2 + \alpha)(X_2 + \mu)}{\alpha S_0(X_2 + \mu + v_2)}$$

The basic reproductive number is given by

$$R_0 = \frac{(X_2 + v)(X_2 + \alpha)(X_2 + \mu)}{\alpha v(X_2 + \mu + v_2)}(1 + \frac{(1-f)v}{\mu})$$

These formulas for $I_0, E_0, U_0, t_0, T_0 \; and \; R_0$ were derived. Their values connect the Phase II reported cases data to the parameterisation and initialisation of our differential equations model.

During Stage II of the pestilence, $T(t) = T_0$ is consistent. At the point when solid government estimates like confinement, isolate, and public closings are carried out, Stage III starts. The circumstance of the execution of these actions, and their effect on illness transmission, is mind boggling. We utilize a dramatically diminishing time-subordinate transmission rate τ (t) in Stage III to fuse these impacts. The equation for a T(t), which incorporates Stage III start on day N, is

$$T(t) = T_0, 0 \le t \le N$$

$$T(t) = T_0 \exp(-\mu(t - N), N < t$$

The date N and the force μ of the public measures are picked so the combined detailed cases in the mathematical re-enactment of the scourge lines up with the total announced case information at a distinguished date after day N. Thusly, we can project forward the time-way of the plague after the public authority forced public estimates produce results.

3. APPLICATION

We apply our model to South Korea, Italy, and Spain ([4, 5, 6]). In Table 1 we provide the parameters for these three countries.

Country	X_1	X_2	t_0	t_1	μ	N	S_0	f	T_0	R_0
India	0.087485	0.0959	Feb 2	Feb 8	0.6	Feb 22	51, 700, 000	0.8	0.000520105531	0.0614103817
China	0.07902	5.306451	Feb 24	Mar 3	0.6	Mar 8	60, 500, 000	0.8	0.00504750779	308.092818
Pakistan	0.10804	12.8918	Feb 8	Feb 18	0.6	Feb 27	46, 700, 000	0.8	0.00950704982	1647.84882

Table 1: The parameters χ1, χ2 are obtained by fitting χ1 exp(χ2 t) − 1.0 to the cumulative reported cases data between the dates [t1, t2] for each country: (1) t1 = February 22 to t2 = March 1 for South Korea; (2) t1 = March 12 to t2 = March 21 for Italy; (3) t1 = March 13 to t2 = March 21 for Spain. The values of I0 U0, τ0, t0, τ0, and R0 are obtained by using (3.2), (3.3), (3.4), (3.5). The parameters ν = 1/6, η = 1/7, α = 1/1, χ3 = 1.0, and R0 = 1.0 for all three countries.

3.1 COVID-19 epidemic in India

The epidemic in South Korea can be divided into four stages:

1) Before February 2: Phase I.
2) February 2 to February 12: Phase II.
3) March 2 to March 8: Phase III. The South Korean government implemented extensive testing, isolation, and contact tracing of confirmed cases, and quarantine policies after February 20, which took effect in daily reported cases after February 2.
4) After March 8: The daily reported cases were approximately the same each day and the cumulative reported cases increased linearly. This stage corresponds to a new Phase I, with a low level background generation of reported cases each day. To account for this new Phase I, the model (2.1) is modified by replacing $T(t)$ with a new transmission function $T(t, S(t), I(t), U(t))$ that depends on $t, S(t), I(t), U(t)$ as follows:

$$T\big(t, S(t), I(t), U(t)\big) = 0, t_0 \le t \le 11; \quad T\big(t, S(t), I(t), U(t)\big) = T_0 \exp(-0.6(t - 11), 11 < t \le 30; \; T\big(t, S(t), I(t), U(t)\big)$$
$$= 23.0\, T_0 \exp(-0.6(30 - 11))(\frac{S(30)[I(30) + U(30)]}{S(t)[I(t) + U(t)]})$$

The value 23.0 is chosen to match the slope of the linear increasing cumulative reported cases data after day 30. The equations and initial values are the same, except for this new τ function. The formulas in connect the new Phase I to the transmission rate in the model equations, and to the model outputs of $E(t), I(t), U(t), R(t), CU(t), CR(t), DR(t)$. The form of can be applied to other examples which transition from Phase III to a new Phase I, corresponding to a linearly increasing growth rate of cumulative reported cases. This new Phase I can further transition to another Phase I with slower linearly increasing growth rate,

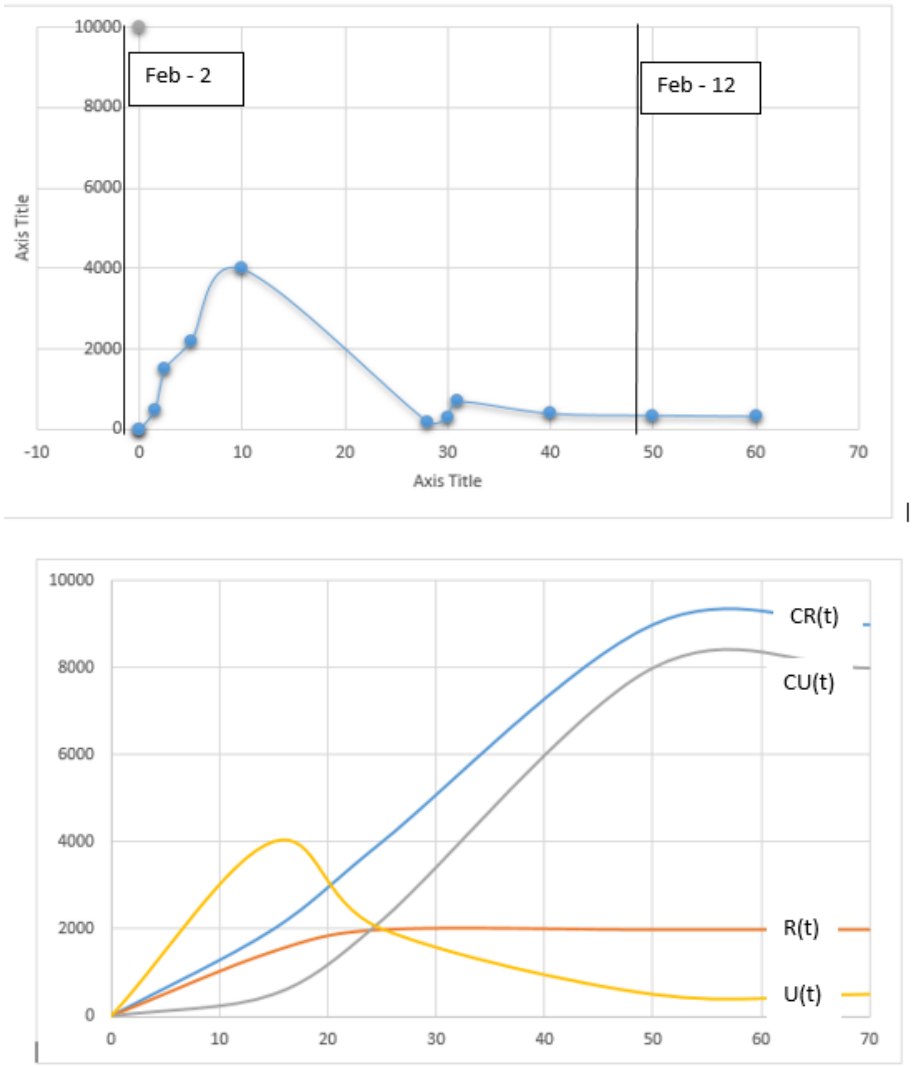
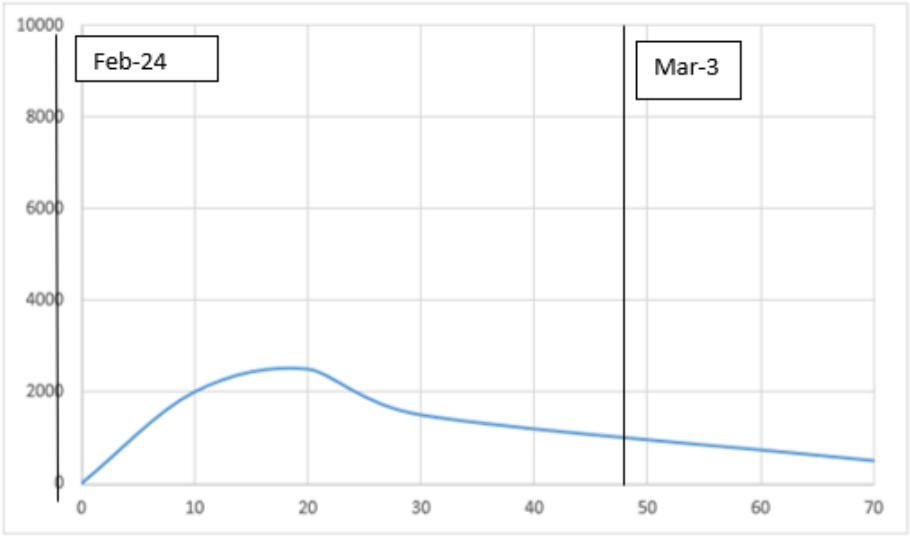


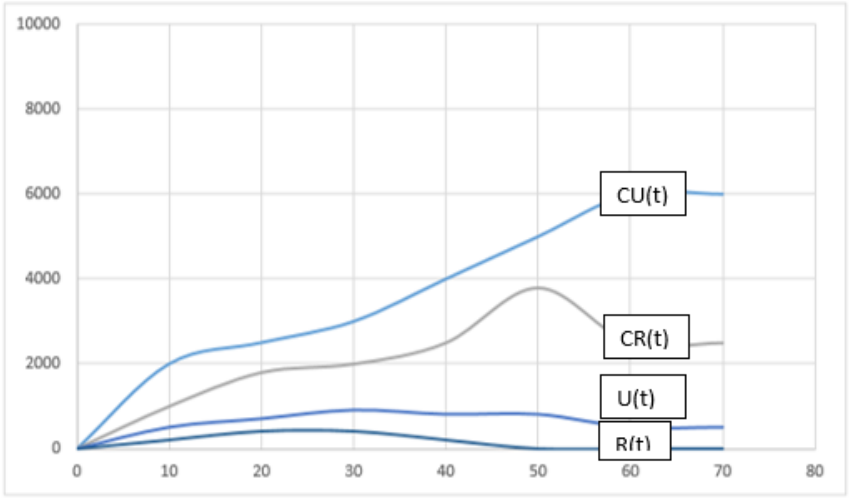
Fig. 2: Model simulation for South Korea: Left side - cumulative reported cases: shaded region = Phase II, model turning point = February 7. Right side - daily reported cases: model turning point = February 2

3.2 COVID-19 epidemic in china

The epidemic in Italy can be divided into three stages:

1) Before February 24: Phase I.
2) February 24 to March 3: Phase II.
3) Beginning February 27, the Italian government implemented extensive public regional lockdown measures, which were extended to all of Italy on March 3. These measures took effect in reducing reported daily cases approximately two weeks later. We take Phase III to be March 20 onward.

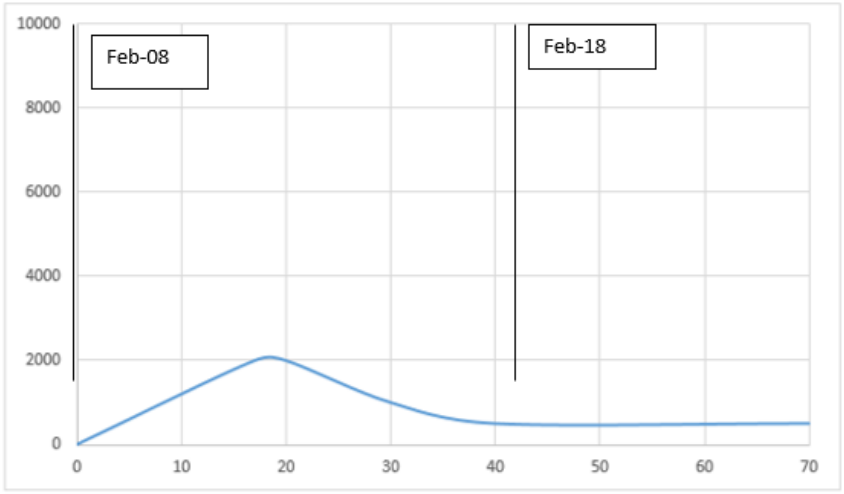


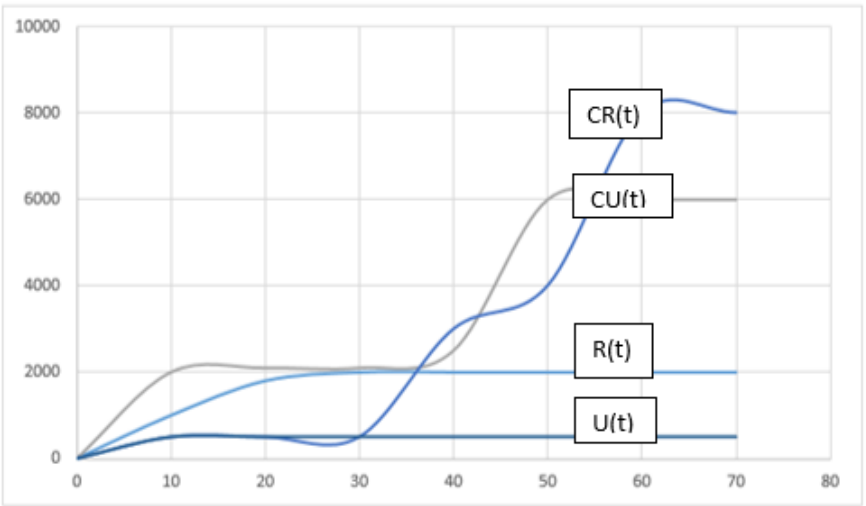


3.3 COVID-19 epidemic in Pakistan

The epidemic in Spain can be divided into three stages:

1) Before February 8: Phase I.
2) February 8 to February 18: Phase II.
3) On February 8, the Spanish government implemented partial shutdown measures, and on February 18 imposed a general state of alarm on all of Spain. These measures took effect in reducing reported daily cases approximately two weeks later. We take Phase III to be February 27 onward.





4. CONCLUSION

We have applied a strategy created in [1], [2], [3] to anticipate the advancement of a Coronavirus pandemic in a geological area, in view of announced case information in that district. Our model spotlights on unreported cases, asymptomatic irresistible cases, and the division of the plague advancement through a progression of stages. Our technique can be prescient, when the pestilence is filling dramatically in Stage II. In [1] we showed a strategy to distinguish the Stage II dramatically expanding pace of combined announced cases. At the point when public measures are started in Stage II, to enhance the pandemic, we model these actions with

a period subordinate dramatically diminishing transmission rate. These actions bring about an ensuing decrease in day by day revealed cases, which we call Stage III. We decide the progress from Stage II to Stage III, which may require over seven days, in the model reproductions. For INDIA, the plague has lessened, in view of the significant estimates that were carried out to confine public removing. These actions included observation, broad testing, detachment and contact following of announced suspected and cases. The total number of revealed cases in India, be that as it may, has not straightened, yet rather is developing directly at a low rate. For I China and Pakistan, the plagues have clearly passed the defining moment, as per the day by day detailed cases information. The total revealed cases may not level, yet as in India, will keep on developing straightly at a low rate. Our model joins government and social removing measures, through the time-subordinate transmission rate T. It is obvious that these actions should begin as ahead of schedule as could really be expected, and ought to be just about as solid as could be expected. On the off chance that the plague dies down considerably because of these actions, the case of India shows that a foundation level of every day cases may persevere for an all-inclusive time. On the off chance that major separating measures are diminished too soon or too widely, the pandemic may get back to new Stage II, with dramatically expanding total cases. A potential control of Coronavirus pestilences is proven by the case of India. The eventual fate of Coronavirus pestilences and their human cost is at present unsure, and it is cheerful that numerical models can be useful.

5. REFERENCES

[1] Z. Liu, P. Magal, O. Seydi, and G. Webb, Understanding unreported cases in the 2019-nCov epidemic outbreak in Wuhan, China, and the importance of major public health interventions, MPDI Biology, 2020, 9(3), 50.

[2] Z. Liu, P. Magal, O. Seydi, and G. Webb, Predicting the cumulative number of cases for the COVID19 epidemic in China from early data, medRxiv, 2020.

[3] Z. Liu, P. Magal, O. Seydi, and G. Webb, A COVID-19 epidemic model with latency period, to appear. [4] https://en.wikipedia.org/wiki/2020_coronavirus_outbreak_in_South_Korea [5]

