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On the Origin, Transmission and Consequences of the COVID-19 Virus to Human Lives in India: With Special Reference to Kerala State

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Abstract: Humanity has often been taken by surprise by new strains of microorganisms that adversely affect human life expectancy. The coronavirus outbreak is causing an unprecedented global health emergency and a global economic slowdown. Epidemiologists are aware of various specimens of viruses like the ones that cause Malaria, for instance, and scientists have been able to meet such threats by introducing drugs that make them perish at a rapid pace so that the natural human resistance to meet such attacks become sufficient for the patients to return to normal health. But viruses also try to survive by transmuting themselves into different strains that are capable of overcoming the existing antiviral drugs. Probably, COVID-19 may be one such transmutation. Hence the main objectives are to study how the COVID-19 virus affects the population and at what stage and time the epidemic will abate. As primary data is challenging to get, we use ICMR and other Govt. publications for the related information. Simple demographic and statistical methods are used for the analysis. At the early stages of the infection, we have no protocol on how to approach the virus. But now the health department has the protocol and thus even though we have no medicine, we are able to increase the recovery rate and flatten the mortality. Thus by following government and health workers' directions – Break the Chain movement – one can make sure that one is safe and also the people around him. So governments need to take measures for testing as many people under observation as possible and assess their COVID-19 status at the earliest.

Keywords: COVID-19, Infection rate, Disease reproduction rate.

Introduction

Humanity is often taken by surprise by new strains of microorganisms that adversely affect human life expectancy. Currently we are facing a virulent, aggressive virus called COVID-19. At present, we don't have answers to questions like how it originated, how it spreads, how long a specimen of this virus survives and what conditions are not propitious to its multiplication and survival - the WHO has classified this as a pandemic. To understand the ways to meet these challenges, we have to study how it affects the population and at what stage and time the pandemic will abate.

Epidemiologists are aware of various specimens of viruses like the one that causes Malaria, for instance. And scientists have been able to meet such threats by introducing drugs that make them perish at a rapid pace so that the natural human resistance to meet such attacks become sufficient for the patients to return to normal health. But viruses also try to survive by transmuting themselves into different strains that are capable of overcoming the existing antiviral drugs. Probably, COVID-19 may be one such transmutation. That may be its origin, but how it gets transmitted to humans? For Malaria, the mosquito was a carrier or vector as it bites one infected human and then bites another uninfected human and so on by

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forming a chain that seems endless. Breaking such chains that spread the contagion is not a new idea. It worked with Malaria by severely controlling the carrier virus – thus breaking the chain. Fortunately, microorganisms have a very short life span individually maybe a few hours before which they find a host to proliferate offspring. But viruses, unlike bacteria, manage to survive in non-porous surfaces perhaps for a week even though they are known to perish on porous materials like cloth and paper. During such survival period, they wait for circumstances to launch on to hosts to multiply. They are carried generally by humans themselves and create a long chain of such multiplication and proliferation. It is this probable way in which the virus attack humans that leads one to think of breaking the chain by cleansing the human body itself that come into contact with the virus and by creating an atmosphere hostile to its survival. The frequent hand wash advisory in Kerala results from such Break the Chain concept using soap or alcoholic sanitisers in which the COVID-19 perishes. But that is not enough. It can remain silently on non- porous surfaces for some days. So, non-porous surfaces in homes and offices also have to be cleaned frequently to eliminate this menace. Once inside the hosts, we cannot destroy the virus unless we have a proper medication to support the natural human resistance to such attacks as yet no singular remedy has come against COVID-19. But a mixture of such remedies that destroy other viruses seems being attempted by medical practitioners with some success. But the pace of spread that causes mortality is such that one wonders whether the critical size of the human population is sufficiently high for the disease to die out like many other epidemics which subsided. Like the viruses, humans also naturally develop their mechanism to fight it by enhancing their immunity. They learn this process through the experiences of humans on whom the virus is proliferated. If the size of the population of humans is critical or less than that, the game is won by the virus. So it is worthwhile estimating the critical population size that naturally restores the balance in favour of humans, provided we cannot find any other measures to eradicate this menace soon enough.

Data and Methodology

Let P be the population of humans exposed to the risk of COVID-19 attack. A portion of this population, say M, is able to withstand the attack from naturally possessed immunity. The balance $S = P-M$ is at risk. Let S be the population at risk (under observation or quarantine). Let β be the rate of transmission among susceptible individuals, S. Then the infected would be $I = \beta^*S$. Once infected, the human will be under medical care or would work out his natural resisting power and may recover. Let γ be the rate of recovery, given one is infected. We shall now introduce a concept introduced by demographers like Bailey (1975) and Murray (1993), designated as the reproductive rate of the disease caused by the virus, (R). R is the number of secondary infections created by one primary infection. We also recall that the concept of the epidemic threshold, which is $\rho= (\gamma/\beta)$. Now we define $R =1/\rho^*\sigma$ where σ is the fraction of susceptible in the population to infection because susceptible does not mean each and everyone coming in contact will be infected. After all, existing immunity due to any cause can ward off the attack. We notice that γ is the recovery rate and β is infection rate, and so ρ will be less than one if the recovery rate is less than the infection rate. As a result, the Reproduction rate, R will be greater, the smaller the ρ and vice versa. When R is greater than one, it means that on an average, each infected case can produce more than one further infected case in the population. That means an epidemic is on its course. On the other hand, if R is less than one the average number of individuals further infected by one already infected will be less, and so over time, the disease will vanish.

Results

Of the 4443 cases reported as on 30th June 2020 in Kerala, 684 are cases infected by already infected, and 3759 are imported (people from other countries and other states of the country) infected, including seven foreign migrants. Rate of transmission on this basis is 684/4443 = 15.4 per cent per infected immigrant. We take it that about 1000 cases are at one or other kind of quarantine. Assuming that the transmission rate will increase due to increasing quarantine at 5 percent per day and percentage of quarantine evaders taken at 10, the expected rate of further increase is = 1000 x .05 x 0.10= 7.5 percent per day over previous day total infected leading to a total of 7.5+15.4 = 22.9, that is, 23 per cent on all counts. Of the 4443 cases reported as on 30th June 2020 we expect to have infected number = 4443x1.23= 5465 on 1st July 2020. The actual number as on 01-07-2020 is 7075 [4594(total infected) +2456(cured cases)+25(death)].

From the available statistics, we estimate that from the infected on an average 50.12 per cent recover (average for the last three months, April, May and June). Hence our γ for Kerala is 50.12 per cent. Not all the immigrated are infected, and we assume that about 20% will be infected immigrants and expecting a daily rate of immigrants as 100, the effective transmission rate can be taken as 20% * 23% * 100= 4.6% of the total immigrants. Hence our β for Kerala is 4.6% and hence the threshold population index comes to $\rho = (\gamma/\beta) = 50.12/4.60 = 10.90$. The disease reproduction rate R as defined above works out to $(1/\rho) * \sigma = (1/10.90) * 0.01625$ (the proportion of the population under the observation of the States total population) = 0.1491, i.e. far less than 1. [At the end of 2nd lockdown, i.e. on 14th April 2020 the number of persons under quarantine reached up to 1,71,355. Then it started to decline and reached 16,693 persons under quarantine, again after 8th May, 2020, as per the Govt. of India's decision the migrant people started coming back to Kerala. Thus persons under quarantine increased, and it reached 411516 as on 30th June 2020. Thus the total number of cumulative persons under quarantine comes around 5,66,178, which comes around 1.625 per cent of Kerala's 2011 total population]. This suggests that the disease as it now affects recovery rates as calculated and also proportion susceptible to attack is 20percent. The threshold population of immigrants acceptable can thus be estimated as total immigrants as on date 1st July 2020 = 1000 x4.6 =4600 and anything more than this would make R greater than one and so would cause an epidemic outbreak among the resident population also.

Table 1: COVID-19 Status for India and Kerala

Date	India			Kerala		
	Average no. of Infected cases	Average % of recovery	Average no. of deaths	Average no. infected cases	Average % of recovery	Average number of deaths
Up to March 2020	181 (total)	------	43	209(total)	-----	1
1-7 April 2020	479	4.63	93	16	13.72	1
8-14 April 2020	905	7.85	247	7	35.01	1
15-21 April 2020	1216	12. 37	497	4	63.00	0
22-30 April 2020	1842	20.59	888	10	73.70	1
1-7 May 2020	2986	23.69	1526	1	85.00	0
8-14 May 2020	3725	27.82	2292	5	94.83	0
15-21 May 2020	5197	35.74	3108	19	81.81	0
22-31 May 2020	6961	42.37	4299	54	52.08	6
1-7 June 2020	9194	47.75	59191	86	43.98	5
8-14 June 2020	10769	49.14	7839	86	42.06	17
15-21 June 2020	12459	53.16	11037	93	48.48	20
22-30 June 2020	20179	58.05	14904	141	52.12	22
1-7 July 2020	22740	60.59	16367	207	57.63	26

Source: The data taken from the COVID Dashboard of Government of India and Government of Kerala

From Table 1, we can see that in India, there were 181 infected cases and 43 deaths reported up to 31st March, 2020, and similarly 209 cases and one death in the state of Kerala. On average, 479 infections were reported in the first week of April in the country, and it increased to 14 times of this figure (6961) in the last week of May. Again the cases increased to 18 times that of April first week to the first week of June. In the first week of July the average number of infected cases increased to 22740. The average number of deaths was 93 in the first week of April, but it reached 4299 in the last week of May, and it became more than 6000 in the first week of June. Further the average number of deaths increased to more than 18000, in the first week of July. The average recovery rate increased from 4.63 per cent to 58.05 per cent during the last week of June. In Kerala, 16 infected cases were reported in the first week of April, and then cases started to decline up to the second week of May, but after that, an increase in the cases of infection was reported. Majority of these cases are people coming into the state from abroad and other states. There were 16 deaths were reported, out of these 11 cases were in the last week of May and the first week of June and the number of deaths increased to 22 by the last week of June.. The recovery rate was 13.72 per cent in the first week of April, it reached 95 percent in the second week of May and then started to decline to 44 percent in the first week of June. We expected this because most of the recent infections are imported cases from abroad and other states, and the recovery rate has started to increase and reached to 57.63 in the first week of July.

R- is a measure of disease reproduction rate. If R > 1, it indicates potential spreading of the disease and R < 1 indicates abatement of the disease trend. R values are calculated based on some assumptions about the infection rate. True Infection Rate is difficult to calculate as we must know the percentage of the population yet to be exposed. We can only conjecture about this figure and considering the wide variation of the rate of spread seen in different states, it is possible to estimate the likely percentage immune, and it will change with the spread of the disease. The rate of spread is again a matter of surmise.

Table 2: Reproduction Rate (R) for India and Kerala

Date	India			Kerala		
	With Infection Rate 10%	With Infection Rate 15%	With Infection Rate 20%	With Infection Rate 10%	With Infection Rate 15%	With Infection Rate 20%
1-7 April 2020	1.66	2.47	3.19	0.70	1.03	1.33
8-14 April 2020	1.41	2.08	2.69	0.29	0.42	0.55
15-21 April 2020	0.89	1.31	1.70	0.16	0.24	0.31
22-30 April 2020	0.54	0.79	1.02	0.14	0.21	0.27
1-7 May 2020	0.42	0.62	0.80	0.12	0.18	0.23
8-14 May 2020	0.36	0.54	0.69	0.11	0.19	0.21
15-21 May 2020	0.29	0.43	0.56	0.13	0.13	0.25
22-31 May 2020	0.24	0.35	0.45	0.19	0.19	0.36
1-7 June 2020	0.22	0.37	0.47	0.24	0.36	0.53
8-14 June 2020	0.21	0.32	0.42	0.25	0.37	0.47
15-21 June 2020	0.20	0.29	0.39	0.21	0.32	0.42
22-30 June 2020	0.18	0.27	0.37	0.21	0.38	0.39
1-7 July 2020	0.17	0.26	0.34	0.19	0.34	0.35

It is in this background that the isolation of immigrants and person to person contacts within the resident population may play a role to mitigate the menace. Since total isolation of immigrants is already seen not realised, there is already disease incident probability within the resident population. It thus justifies controlling the rate of transmission from person to person from within the resident population by the lockdown. The success of the lockdown depends on what maximum rate of attack would ultimately result; given the chance of average recovery is 50.12 per cent in Kerala. In order to have the pandemic subsided; we must achieve a rate of transmission significantly less than 4.6 percent per day within the resident population so that our R for the resident population would be 4.6 x .20 = 0.1, again assuming that 80 percent of the resident population is immune to the virus attack.

Figure 1: COVID Status in India as of June 30, 2020

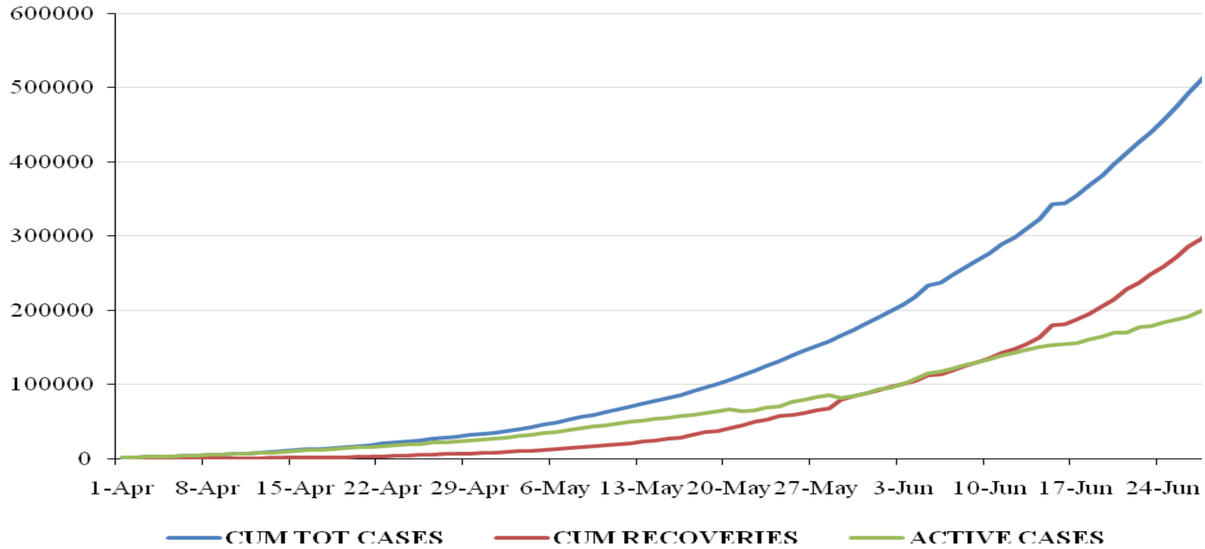


Figure 2: R Values at different rates of Infection in India keeping Recovery rate as experienced on June 30, 2020

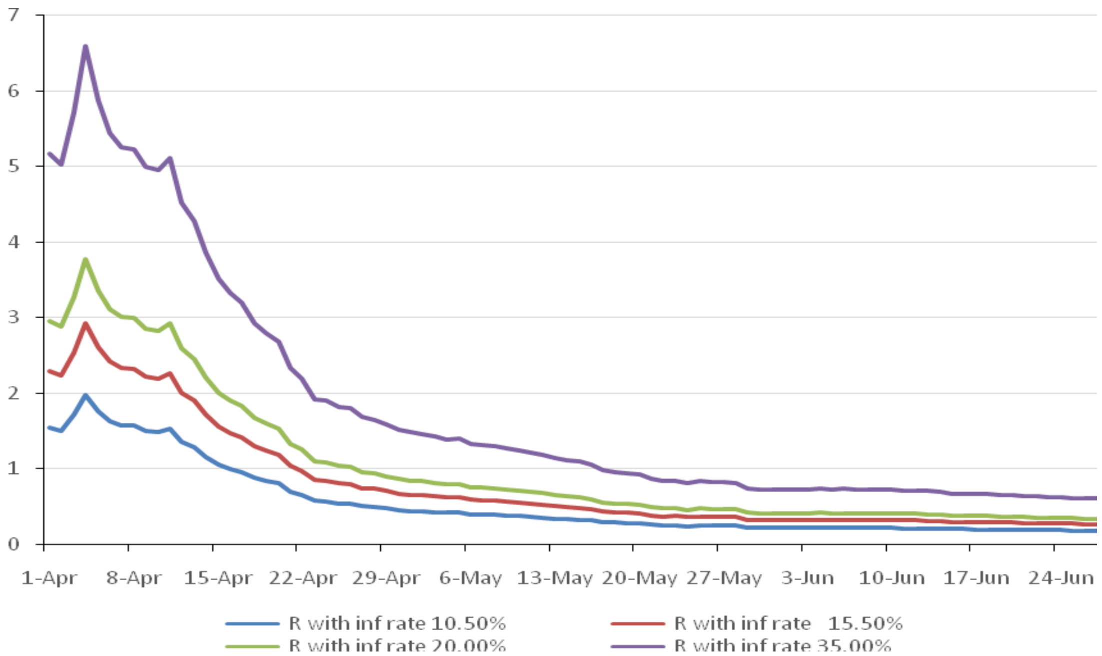


Figure 3: COVID-19 Status in Kerala as on 31st May June 30, 2020

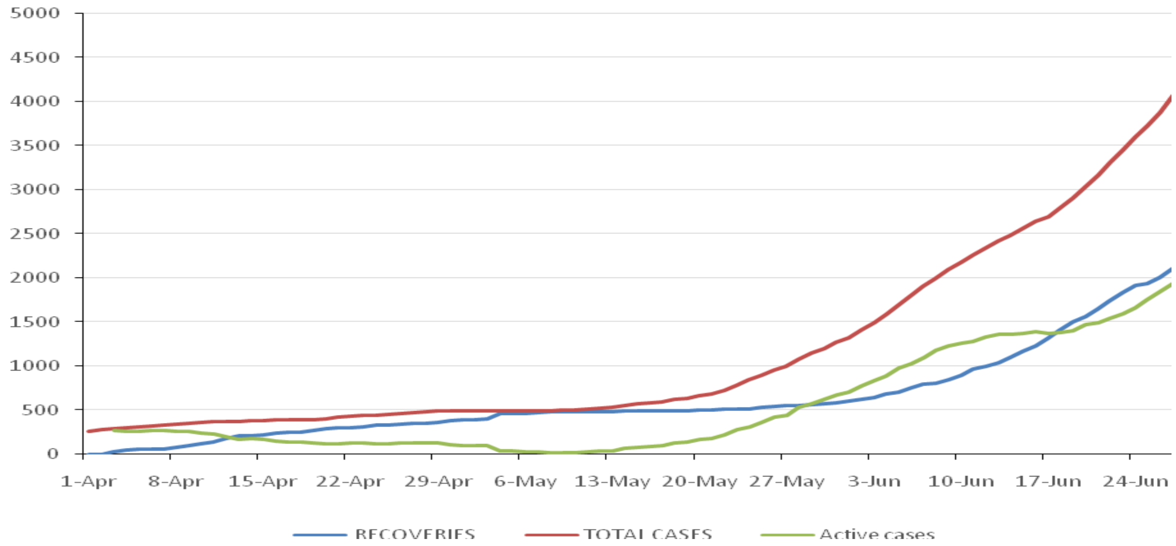
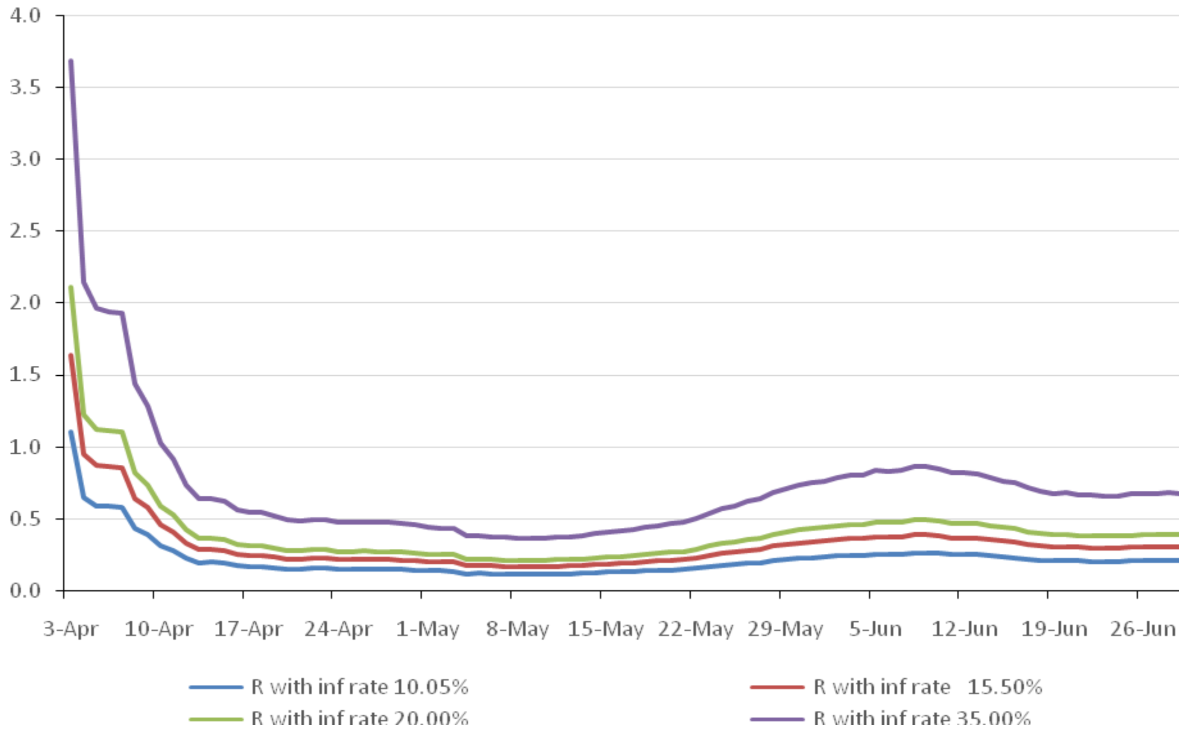


Figure 4: R values at different Infection Rates keeping Recovery rate at the experience as of June 30 in Kerala



The population of Kerala is 3,38,52,000 (2011 Census), and the probable susceptible to attack would be 5 percent of this is 1692600. The daily rate of attack taken at 4.6 per cent of the total resident population getting infected would be 1692600*0.046= 77860, i.e., about 80,000. For the disease to be in effective control, the recovery rate must be sufficiently higher than 50.12 per cent. If that is achieved while the virus is attacking the susceptible resident population, the recovery process will also take place at a rate higher than 50.12 per cent, say 90 per cent, so that the chance of reproduction of infection overstepping the recovery rate will begin to fall. The disease will be on its way out of the population. For this to happen, Kerala must be ready to give effective treatment for at least 80,000 people.

However, this potential 80,000 infected number can be reduced substantially if the Break the Chain, Social Distancing, proper wearing of the mask, hand washing and quarantine movements, along with the great effort of the Kerala Government to control the disease are remarkably successful. Ideally, as a result of these movements along with quarantine of the immigrants, on average, a person infected is effectively controlled to produce only 0.10 proportion of further infection. In that case, the expected number of infected will fall from 80,000 to about 8000 infected. Suppose the infection affected to be about 15 per cent of the population, the infected cases become 12000, and again if it will be 20 per cent, the infected cases become around 16000. At the most if the infection rate increases to 30 per cent the infected cases will become 24000. All these figures are manageable.

However, the mortality arising from the infection will be there to contend with, and on the expected controlled 8000 infected persons, the probable number of deaths could be not less than 8000*0.005402 = 43 (There are 24 deaths on 30th June) . If the infected cases become 15 per cent, the death will increase to 65. If the infection is about 20 per cent, then the number of fatalities raise to about 86. To reduce this risk, we must have adequate treatment for the disease, which produces a fool proof remedy. For this to happen, the recovery rate must be somewhere 95 per cent, which is now 50.12 per cent.

At the national level as we do not have reliable statistics on the number of infected immigrants and contractual infections, here we assume that the rate of transmission is 30 per cent. We take it that 1000 cases are at one or the other kind of quarantine. As in the case of Kerala, assuming that the transmission rate will increase due to jumping quarantine at 10 per cent per day and percentage of quarantine evaders taken at 10, the expected rate of further increase is 1000x 0.10x0.10 =10 per cent per day over the previous day, total infected leading to a total of 10+ 30 = 40 per cent. So on 6, 01, 574 cases were reported as on 30/06/2020, we expect to have infected number = 6,01,574 x 1.40 = 8,42,204, on 01/07/2020. The actual cases as on July one is 10,14,097 including 59.92 per cent cured cases and 17,809 deaths.

From the available records, it is estimated that from the infected on an average (based on last three months, April, May and June, 2020) 32 percent (γ) recovered. Not all the immigrants are infected, and we assume that 20 per cent are infected immigrants and expecting a daily rate of 100 immigrants the effective transmission rate can be taken as 20% x 40%x100 = 8.0%(β). Hence our β for India is 8 per cent and hence the threshold population index becomes $\rho = (\gamma / \beta) = 32/8 = 4.0$. The disease reproduction rate (R) as defined above, works out to be $R = 1/ \rho \times \sigma$ (the proportion of persons under the observation of India's total population) here as we do not have the exact number of persons at surveillance, we assume that it is the same as that of the Kerala State. Hence R = (1 / 4) x 0.01625 = 0.003150 = 0.3125, that is, R is less than one. The threshold infected persons acceptable can thus be as on the date 01/07/2020 = 1000 x 8 = 8000 anything more than this make R greater than one and so would cause an epidemic outbreak. At the national level, it can be seen that an average of 20179 new cases of infection was reported during the last week of June, 2020. This surely indicates the possible community spread of the virus in the country.

Our national population was 121,01,93,422 (2011, Census) and as the country's infected cases are increasing daily if we assume that the probable susceptible to attack would be 10 percent of this or 12,10, 19, 342 in absolute terms. Thus we take the daily rate of attack as 8 per cent of the total resident population, and therefore those getting infected would be 12, 10, 19, 342 x .08 = 96,81,547. For the disease to be in effective control, then, the recovery rate must be sufficiently higher than the present rate of attack. For this to happen, the country shall be ready to give treatment for at least 97 lakh persons, which is an unmanageable figure. However, this potential number can be further be reduced substantially by the programmes mentioned earlier. Assume on an average a person infected is effectively controlled to produce about 10 per cent further infection. In that case, the expected number infected will fall from 96, 81,547 to around 9,68,155, that is, roughly ten lakh persons and this is a manageable number. If the infection rate is 15 per cent, then the infected cases will rise to 14, 52, 232. Further, if the rate will be 20 per cent, the number of cases becomes 19,36,309. Further if the infection rate is 25 per cent then the number of cases raise to 24,20,387 and with 30 percent infection the number cases becomes more than 29 lakhs. But even though the number of infected cases is increasing rapidly, the recovery rate is on increasing trend and the mortality curve is flattening.

As on June 30, the number of deaths is 17421, that is, 2.90 per cent. Then the probable number of deaths from the infected expected cases (9,68,155) could be not less than, 28,076, i.e., nearly 28000 deaths. Again if the rate of transmission is 15 per cent, the number of fatalities will rise to more than 42,000, and if the rate is 20 percent, it may reach more than 56,000. Again if the infection rate increased to 30 percent the fatalities will be around 85,000. To reduce this risk, both the government and the public need to make some urgent measures for the containment of the epidemic. For this, the recovery rate must be more than 90 per cent, and we need to take steps to avoid the death of infected persons.

How long can the pandemic last?

We attempted to estimate this by applying some parameters we have earlier assigned to this malady some based on data and some based on assumptions. We have estimated that for Kerala, the rate of infection is 15.4 percent of the infected population. We have also estimated the recovery rate as per available data as 50.12 percent. The rate of infection is 15.4 percent during the observation period taken as a unit (Three months approximately), and assume disease infection will continue as of the previous unit of time, 15.4 percent and the recovery rate increased to 90 percent from the present rate. Then it will be 15.4 x (1-0.90) percent in the next unit of exposure, i.e. , after three months. In this way let us assume that after n units of time the disease will vanish making 15.4 per cent to an insignificant level of 0.001 per cent of infection rate. This leads to the equation $15.4 \times (1-0.90)^n = 0.001$ and solving for n, we get n =4.2 unit of months, i.e., more than 12 months approximately. That is if the infection rate continues as in the reference period, that is, April, May and June and increase the recovery rate into 90 per cent from the present rate it will take more than 12 months to curb the COVID-19. If the recovery rate increases only to 80 per cent it will take about eighteen months as the lasting period. Thus we can calculate the lasting period of the virus per unit of time (three months).

At the national level, we assumed the infection rate as 30 per cent, and the average recovery rate is 32 per cent for the last three months, and it rises to 58.00 per cent in the last week of June. Again in the first week of July, on an average 60.00 per cent of the infected persons are cured. So if we consider 30.00 per cent as the infection rate and recovery rate as 90 per cent, then it will be 30 x (1-0.90) per cent in the next unit of exposure, $30 \times (1- 0.90)^n = 0.001$; n = 4.48, i.e. nearly 14 months. If the recovery rate enhanced to 80 per cent, n = 6.4 months. That is, it will take nearly 20 months to curb the virus. But from June 2020 is the unlocking period with more freedom for movements and in the field of business with restrictions put forward by the Health Department. This leads to an increase in the infection rate as well as deaths. More than four lakhs infected cases were reported in the month of June and 11900 deaths occurred during the period.

Discussion and conclusion

The first COVID-19 infection in the country was reported in Kerala on 31st January 2020, and in March and April, there was an increase in the epidemic in the state. But only ten infected cases were reported in the first week of May with zero cases in some days. This success is due to the stringent measures in which the state had been implementing the safety precautions against the pandemic, including physical distancing, hand washing, the universal wearing of masks and the early quarantine of all possible suspect cases and their contacts. The slow and steady change in the pattern in COVID-19 related mortality in the state during the past one month (May) was more pronounced on 5th June, 2020, when three deaths were reported in a day in the state, taking the death toll to 16. Kerala's COVID-19 case burden, mortality rate and disease transmission pattern underwent a drastic but expected change after 8th May when the post-lockdown return of Keralites from abroad and other parts of the country, where the virus transmission was intense, started which altered the disease epidemiology. With active cases rising and recoveries stagnating, the trends continue to worsen. However, the disease reproduction rate (R-value) remains below one. This situation has to be expected out of the influx of persons into the state, possibly on the belief that Kerala will make them safer and cure those who are infected. But the situation is not alarming because recoveries, though stagnating, are far higher than active cases. The situation is likely to improve in another fortnight if the influx is controlled or effectively screened, and the influx remains within the manageable levels. At the same time, recoveries on those newly put in the hospital will take some days to happen, so that number of recoveries will start rising again.

A small portion of those who had returned to the state after 8th May, from abroad and from other states had tested positive for COVID-19, of the 1,77,033 persons (not tested all) who had come just 680 had been diagnosed with the disease, with 343 having come from abroad and 337 from other states. The test positivity rate on 31st May is 1.7 per 100 persons while for India it is 5 per 100. For South Korea, the rate is less than 2 per cent, and globally it is trying to reduce below 2 per cent. Kerala has achieved this rate at present. The case fatality rate is 0.541 per cent, but it is nearly 3 per cent for the country.

Even though the number of infected cases is increasing in India, the number of recoveries is also increasing. Further, the death rate was more than three per cent up to the last week of May. After that, it declined and stagnating around 2.8 per cent, that is, we will be able to flatten the mortality curve. So we can hope for a better result in the future. The only visible outcomes of any infection leading to disease are either fatality or recovery. If we go by the fatality, not only the lowest number of deaths is in Kerala, but the rate of mortality on account of COVID-19 is 0.541 per million population assuming that the entire population is exposed to the disease. The worst outcome is fatality, and recovery rate will unwind only over time since the curative duration may not remain constant.

Furthermore, fatality outcome cannot be suppressed. So the performance of a state against the epidemic is best reflected by the mortality, and not necessarily by the recovery rate for the reasons stated above. Kerala model of development is globally well known. Similarly in the case of Covid -19 pandemic the state's approach or model to curb the virus is very humane. The salient features of this method are the early implementation of rehabilitation packages, early detection of COVID-19 cases, quarantine with free accommodation and food, free accommodation for guest labourers from other states, provision of food to about three lakh people through community kitchen during the lockdown period, provision of food by the Anganwadi Centre to children at their own home, sincere efforts by the health workers and civil police officers, distribution of two million masks and 5000 hand sanitiser packets by Kudumbashree and above all the responsible behaviour of the state's educated civil society. Thus the achievements of Kerala stand head and shoulders above the rest of the country.

What we need to flatten is the steep mortality curve. People who are at risk of high mortality, namely those over 60 years, and those with diabetes, hypertension, heart problems, chronic respiratory disease and obesity are to be protected from the infection, which demanded reverse quarantine of the elderly and the vulnerable. We have far fewer citizens above 60 than the United States or Europe; flattening the mortality curve is eminently feasible and culturally appropriate. The norm in the urban middle class and rural families is to protect old parents and vulnerable family members. Flattening the mortality curve by reverse quarantine would have resonated well with our people and received nation-wide acceptance. ICMR reported that the urban slum population was most vulnerable to the spread, followed by urban settlements.

The analyses may be helpful to analyse how the control measures, including the betterment of recovery rates through medical support, will likely unwind. The best scenario can be bettered if the infection rates are minimised by restricting potential infecting vector inflow into the population, and by increasing the recovery rate and also by effectively screening the unaffected but potentially vulnerable population from those already infected within the population. Measures also are required to eradicate the virus from surfaces other than human hosts by effective disinfection. Since the virus is known to have the capacity to survive for a few days on polished non-porous surfaces, efforts should be there to cleanse such surfaces weekly. At the same time, even though we are continuing Break the Chain movement, from the experience of other countries, there is a chance of an increase in the infection rate after the lockdown period. So governments need to take measures for testing the maximum people under observation and ensure no infection among them at the earliest. If we avoid testing these people, those who have no symptoms of the disease may have a chance of infection after the lockdown period, which may lead to community spread of the disease. Hence, the governments in the state and centre need to take measures to expand the testing for COVID-19.

Limitations

This study is based on data published by ICMR (https://www.icmr.gov.in/) and Govt. of Kerala (https://dashboard.kerala.gov.in/). The progression of the pandemic depends on several extraneous factors. Thus this analysis and the projection given may not be accurate. The purpose of the study is to provide a futuristic perspective of the pandemic.

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