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Herd immunity and Covid19 in India

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Abstract

During current Covid19 pandemic, herd immunity has become a hot topic. In absence of vaccine and specific drug(s) against the virus, it is only the 'herd immunity' towards which we can look for respite from the pandemic. The present paper uses Mathematical formula of 'herd immunity threshold' in completely susceptible population, (as in case of Covid19 pandemic) = $[1 - 1/R_0]$, and finds that in India for achieving herd immunity against Covid19 virus, at least 75% of its population is to be exposed to the virus. Thereafter, increment in proportion of infected population in the country over six days is estimated and date of achieving 75% of infected population is arrived at through extrapolation, which is found to be 17 November, 2020. But since ONE such day can't be pin-pointed in any massive community based biological situation, it is better to say that 'around 17 November, 2020' India will expectedly achieve herd immunity against Covid19 virus. The ascending epidemic curve will start downward slide weeks before 17 November, 2020 and gradually India will come out of the pandemic unless a second wave of pandemic due to mutation of Covid19 virus, for the worse, comes. In the whole exercise a few reasonable assumptions are made. It is immensely expected that the paper might stimulate Epidemiologists to fine-tune the methodology to estimate more valid result in respect of herd immunity in India. There is an issue of re-infections with same Covid19 virus due to early decline of anti-body level in some persons during the present pandemic. These re-infections are seen in a few cases in India. This issue is not significant in the present study as re-infections are asymptomatic or very mild in nature. These will not change the broader picture of the pandemic. But early decline of antibodies may cause problem at another level. It may delay the development of precise herd immunity and Covid19 may continue as low endemic disease in India till a vaccine is developed.

Keywords: Covid19, herd immunity, R-naught (R_0), ICMR, sero-survey

Introduction

For some infectious diseases, herd immunity can go into effect when 40 percent of population is exposed ^[1]. But in most cases 80 to 95 percent of population must develop immunity to stop its spread. In case of Measles, 95 percent vaccination is required for developing herd immunity ^[1].

During current Covid19 pandemic herd immunity has become a very important consideration. As no vaccine and/or specific drug(s) against the virus are available presently, it is only the herd immunity which is looked at for getting relief from the pandemic. Experts estimated that in the USA, 70 percent of the population would have to recover from COVID-19 to halt the epidemic ^[2].

Under the simplest formula, the development of herd immunity in Covid19 novel virus is a function of R_0 (called 'R naught' and signifies basic reproduction number, that is average number of secondary infections caused by a single infectious individual introduced into a completely susceptible population).

Mathematically 'herd immunity threshold' (the proportion of population to be infected to interrupt transmission of an infectious disease) in completely susceptible population, as in case of Covid19 pandemic, is represented by formula ^[3] = $[1 - 1/R_0]$. In USA, the experts placed the country's 'herd immunity threshold' level at 70 percent, because initial R_0 in USA was surely about 3.3. Thus 'herd immunity threshold' = $[1 - (1/3.3)] \times 100 = 70$ percent was found for USA. The present paper attempted to estimate the 'herd immunity threshold' level in India and tried to forecast as to when India could expect to achieve its 'herd immunity threshold' against Covid19 virus.

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Methodology

India reported 10,815 cases ^[4] on 14 April 2020. For India, R_0 was 1.83 during April this year ^[5]. It can be assumed that during beginning of Covid19 pandemic in India (February-March 2020), its R_0 was 2. That way, 'herd immunity threshold' level in India would be 50 percent (by using above mentioned formula of $[1 - (1/2) \times 100]$). But keeping in mind the lowering effect on R_0 due to nation-wide complete lockdown for continuous 68 days ^[6] from 25 March to 31 May 2020, we can add additional 25 percent to India's 'herd immunity threshold' level to reach a compromise of 75 percent.

In a sero-survey report ^[7] of Indian Council of Medical Research (ICMR), it was found that in first week of May this year, there were about 6.4 million of Covid19 infected persons in the country against reported cases of 52,592 on 7th May, 2020. That made the presence of about 122 Covid19 infected persons against each reported case in the country on 7th May 2020. Compromising for the issues of 'sensitivity' and 'specificity' of diagnostic tool(s) used, as

well as, 'confidence interval' related to sampling methodology of ICMR study, it could be reasonably assumed that for each reported case of covid19 in India, there were 100 more unreported infected persons in the country.

Applying the assumption of infected unreported persons in India made above, the population percentage of Covid19 infected persons was estimated from 19 September to 25 September 2020 at 10:30 hours every day. The formula used was: $p = [c + \{c \times m\} / P \times 100]$; where 'p' = population percentage of Covid19 infected, 'c' = total reported cases on the day, 'P' = population of India on the day and 'm' = multiplication factor, which is 100 (number of additional infected persons per reported case). And then the increment in the percentage of Covid19 infected Indian population over those six days was extrapolated to find when India will reach 75 percent of infected population against Covid19 virus.

Results

Table 1: Estimated population percentage of Covid19 infected over days.

Sl. No.	Date	Population of India ^[8] (P)	Total reported Covid19 cases (c) ^[9]	Total population infected $[c + (c \times m)]$	Population percentage of Covid19 infected (p)
1	19.09.2020	1,383,021,004	5,312,537	536,565,937	38.80
2	20.09.2020	1,383,072,132	5,400,922	545,433,122	39.44
3	21.09.2020	1,383,109,470	5,485,612	554,046,812	40.06
4	22.09.2020	1,383,146,908	5,560,105	561,570,605	40.60
5	23.09.2020	1,383,184,377	5,643,481	569,991,581	41.21
6	24.09.2020	1,383,221,846	5,732,811	579,013,911	41.86
7	25.09.2020	1,383,259,317	5,816,103	587,426,403	42.46

From the above table, it is found that population percentage of Covid19 infected persons increased from 38.80 percent to 42.46 percent in six days. In other words, increment in population percentage of Covid19 infected persons of 3.66 percent (42.46 – 38.80) occurred in six days. So, further increment of 32.54 percent (75.00 percent – 42.46 percent) will occur in next $[(6 \times 32.54) / 3.66] = 53$ days, that is on 17 November 2020.

Discussions

India is expected to reach its 'herd immunity threshold' level of 75% against Covid19 virus on 17 November 2020. But since ONE such day can't be pin-pointed in any massive community-based biological situation, it is better to say that 'around 17 November, 2020' India will expectedly achieve herd immunity against Covid19 virus. In the preceding weeks of that date, the current ascending trend of epidemic curve in India will start its downward journey. And after around 17 November, 2020, India will be expected to come out of current pandemic gradually, unless attack of a second wave of pandemic due to mutation of Covid19 virus of worse pathogenicity comes. Two clades of Covid19 virus, namely A2a and A3i are now most dominant in India ^[10]. Pragmatically speaking, we in India have to keep our fingers crossed at the moment. It is highly important to continue with district-based monitoring of Covid19 situation. This has been emphasized in a recent study of same author¹¹ to keep a constant track of the situation and to implement appropriate containment measures in required districts/places.

India is a vast and populous country. So there will be some time variations in achieving 'herd immunity threshold' levels among districts and states. The forecasting

methodology used in the study was simple and supported by a few reasonable assumptions. The result derived from the study is expected to give near-true picture in given situation. The study can stimulate Epidemiologists to fine-tune the methodology to get more valid estimate about 'herd immunity threshold' against Covid19 virus and expected date of achieving that in India.

Issue of re-infection due to declining antibodies needs to be addressed here. As the Covid19 pandemic continues, re-infections are found after few weeks to few months of first infection in some individuals across the world. India, too, has reported a few cases of re-infection ^[12]. It should be noted that in all the cases of re-infection reported till date, patients did not possess enough antibodies to fight the re-infection ^[12].

When antibodies tend to wane over time, the immune system doesn't necessarily have to start again from scratch to fight re-infection. Memory of a past infection can be stored in a cell called a memory B cell. Yet another line of defense is a kind of immune cell called a T cell. Thus, there are many arms with which the immune system can tackle this re-infection ^[13].

Re-infections are common with other Corona viruses. So, re-infection with Covid19 is expected one. It may be possible to become infected again by same Covid19 virus. But the resulting infection will be mild or asymptomatic, with significantly lower levels of virus replication and onward transmission ^[14].

A sero-survey done in Delhi between 27 June and 10 July 2020 has found antibodies against Covid19 virus in 23 percent of surveyed population. Not surprisingly, in 97 persons out of 208, who had previously tested positive, no antibody against Covid19 virus could be found ^[15]. In other

words, among 47 percent $[(97 \times 100) / 208]$ of previously infected people in Delhi, the antibody waned of.

In another round of sero-survey done in Delhi by ICMR during first week of August 2020, about 29 percent of surveyed people showed antibodies against Covid19 virus¹⁵. This gives a low level of estimate about Covid19 infected population in Delhi than what has been found in the present study in context of whole India. But, practically speaking, 47 percent of earlier sero-positives have memory B cell and immune T cell against Covid19. So this 47 percent should be added with 29 percent of later sero-positives. Consequently, the 'virtual sero-positives' in the last sero-survey in Delhi would be 76 percent (29 percent + 47 percent). We know that this 47 percent contributes to some form of immunity to Covid19, but can't objectively say anything about its quantitative effect. If we assume its effectiveness to be 20 percent of herd immunity, then 'actual sero-positivity' during last survey in Delhi (done in first week of August 2020) would be 38.4 percent (29 percent + 9.4 percent), which is nearer to the findings of present study. Re-infection with same Covid19 virus may not be very important from the view point of outcome, as those will be mild or asymptomatic. But early decline of antibodies can delay in development of clear-cut herd immunity. This may allow Covid19 to continue as low endemic disease in the country, till a potent and safe vaccine against it is developed. But around middle of November 2020, it is expected that there will be a paradigm shift, for the better, in the present Covid19 pandemic situation in India.

The report of sero-survey^[7] in India done in the first week of May 2020 by ICMR was taken as basis in the present study. Because at that initial period of pandemic issue of declining antibodies was not expected to be present. The present study took the course of a linear simplistic scenario. The actual situation must be more complex. However, if it can stimulate discussions among Epidemiologists, the purpose will be served. Meanwhile, optimism is the only virtue left with us.

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