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### Covid 19: Need of vaccine induced herd immunity in India

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#### ABSTRACT



Herd immunity is a traditional concept nothing but a form of indirect protection from contagious diseases. It is also called as "herd effect" or "Community immunity" In a mass community, if a high proportion of members in the community are immune, spreading of the disease is reduced even to non-immunized patients. Herd immunity is of 3 types: 1. Through natural infection or innate immunity 2. Vaccine-induced herd immunity and 3. Through injecting a small proportion of pathogens. This study offers an overview of vaccine-induced herd immunity importance in this pandemic and how it will be achieved. The data of basic reproduction number  $R_0$  values for COVID 19 of 10 weeks in India which were estimated by  $R_0$  package in R software are extracted from a research article and taken the mean  $R_0$  value due to fluctuations as well as to avoid great errors by using MS Excel. Herd immunity is calculated by using a standard equation stated as  $R = (1 - P_c)(1 - P_1)R_0$  mean basic reproduction number  $R_0$  for COVID 19 in India was calculated as 1.671 by using MS excel and the herd immunity threshold determines that only 40.16% proportion of individuals need to immunized through a vaccine to achieve herd immunity towards COVID 19 in India and there is no need to be immune everyone. However, this phenomenon was successfully proved in many critical situations in the past. Finally this study concludes that vaccine-induced herd immunity helps us by playing a key role to eliminate the novel coronavirus

**Keywords:** COVID 19; Vaccine; Herd immunity; HIT; Pandemic; Reproduction number.

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Research Article

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protect the non-immunized susceptible people. This herd immunity is of 3 types: 1. Through natural infection or innate immunity 2. Vaccine-induced herd immunity and 3. Through injecting a small proportion of pathogens. Herd immunity is a crucial method of protection for mainly immune deficiency or suppression individuals like HIV, pregnant women and children. It applies only to transmitting diseases. e.g.: Tetanus. Individuals who got immune through vaccine or recovery of earlier infection acts as a barrier in the transmission of disease by reducing or preventing the transmission of disease. This Herd Immunity Threshold (HIT) depends upon the Basic Reproduction Number ( $R_0$ ) and Effective Reproduction number (R). An equation to calculate the HIT is as follows:

$$R = (1 - P_c)(1 - P_1)R_0 \text{ ----- Eq (1)}$$

Where R= Effective reproduction number

$P_c$ = Relation reduction in transmission without any safety measures

$P_1$ = Rate or proportion of immune individuals

$R_0$ = Basic reproduction number without safety measures (it may vary depending on nature, place, time and environmental factors)

#### INTRODUCTION

Herd immunity is a traditional phenomenon also called as "herd effect" or "Community immunity". The herd is nothing but a group. Herd immunity is a form of indirect protection from contagious diseases. It is an important concept for epidemic control. In detail, it states that in a mass community only a proportion of individuals need to be immune either through earlier infection or through vaccine and no need to be immune to everyone. If a high proportion of individuals are immune in the community, they will

### History of herd immunity

How did herd immunity come into existence, this phrase "Herd immunity" firstly recognized by the writing of Adolph Eichhorn in 1916 in the journal of the American Veterinary Medical Association? In 1923, GS Wilson done experiments on mice by his creation of epidemic and later along with WW Topley described the phenomenon of herd immunity in the journal of Hygiene. In 1924, Dudley applied herd immunity to humans and he describes herd immunity in the article named 'Human Adaptation to the Parasitic Environment'. In 1930`s Herd Immunity step into the public health and recognized as a natural/traditional phenomenon after observation of a significant proportion of children get immunized to measles and new infections rate was significantly reduced including unvaccinated children. Later, the concept of herd immunity had become popular more common. This phenomenon was successfully proved in many critical situations and the list of some diseases which applied this herd immunity with their  $R_0$  and HIT are tabulated in (Table 1) (Data source: wikipedia.org). However, some critics had opposed this phenomenon.

**Table 1: List of some diseases which were effectively controlled by vaccine by herd immunity (Data source: wikipedia.org)**

Disease	Basic Reproduction number ( $R_0$ )	Herd Immunity Threshold (HIT)
Measles	12-18	92-95%
Mumps	4-7	75-86%
SARS (2002-2004 outbreak)	2-5	50-80%
Influenza (Pandemic)	1.15-1.8	33-44%

### METHODOLOGY

Data source: We extracted the data of reproduction number for COVID 19 of 10 weeks with an interval of 1 week from 02-03-2020 to 04-05-2020 in India from a research article (reference no.4).  $R_0$  values are calculated by using  $R_0$  package in R software in that article and the extracted data is tabulated in table 02. And graphically represented as (Figure 1). (the graph is designed by using MS Excel) for this data by taking week number on x-axis and  $R_0$  on the y-axis)

**Calculation:** Mean  $R_0$  calculated from the data mentioned in table 02 by using Excel as 1.671 taken as  $R_0$  due to fluctuations and to avoid great errors.

**Table 2:  $R_0$  values with the interval of 7 days up to 10 weeks**

Week (02-03-2020 to 04-05-2020)	$R_0$
1	3.20
2	1.70
3	2.12

4	1.94
5	1.57
6	1.30
7	1.22
8	1.16
9	1.37
10	1.13
<b>Total</b>	<b>16.71</b>
<b>Mean</b>	<b>1.671</b>

Calculating HIT nothing but  $P_1$  by using Eq --(1) as follows:

$$R = (1 - P_c)(1 - P_1)R_0$$

$P_c=0$  because there is no decrease in transmission without safety measures.

If  $R>1$ , the number of cases will increase i.e.; epidemic;  $R=1$ , the disease is endemic;  $R<1$ , the cases will decrease. Hence it is responsible to achieve herd immunity.

Therefore, the data were taken as

$$P_c=0; R_0=1.671; R<1; P_1=?$$

From Eq (1)  $R = (1 - P_1)R_0$  (Since  $P_c=0$ )

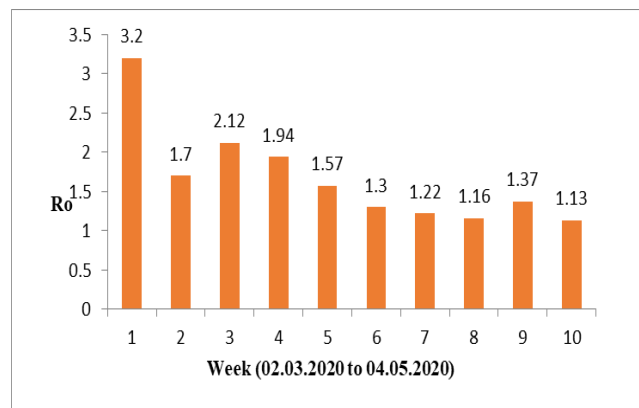
$$P_1 = 1 - \frac{R}{R_0} \text{ (Rearranging the terms)}$$

$$P_1 = 1 - \frac{1}{R_0} \text{ (R<1)}$$

$$P_1 = 1 - \frac{1}{1.671} \text{ (R}_0=1.671)$$

$$P_1 = 1 - 0.5984$$

$P_1 = 0.4016$  In terms of HIT,  $P_1$  value converting into %, HIT= 40.16%



**Figure 1:  $R_0$  values with the interval of 7 days up to 10 weeks**

### RESULTS

The mean basic reproduction number ( $R_0$ ) of COVID 19 in India was calculated as 1.671 and the herd immunity threshold (HIT) at  $R<1$  was calculated as 40.16% which determines that only 40.16% proportion of individuals need to immunized through a vaccine to achieve herd immunity towards COVID 19 in India.

### DISCUSSION

Herd immunity is achieved only when one infected person in the community generates  $<1$  secondary case i.e.;  $R < 1$ . This  $R$  values for COVID ranges from 2.5 to 4 with no clear geographical pattern. In India,  $R$ -value on an average noted as 1.81 on 1st April and declined to 1.04 on 9th May and a slight increase to 1.14 on 17th May. Some states like Punjab, Tamil Nadu, Andhra Pradesh lies  $R < 1$  with 0.69, 0.694, 0.99 respectively have more chances to develop this herd immunity. At present Asymptomatic cases noted more than Symptomatic cases due to Serial Interval Rate (SIR) less than Incubation period. For detecting those cases as well as to achieve  $R < 1$ , the only option was to increase the rate of conducting tests as earlier as possible. Herd immunity induced via vaccination contributed to the eventual eradication of smallpox in 1977 and reduced other pandemics. This shows how herd immunity plays a key role in the elimination of contagious diseases. Herd immunity is often accounted for when conducting cost-benefit analyses of vaccination programs. Therefore, in the inclusion of cost analyses, it results both in more favorable cost-effectiveness or cost-benefit ratios.

## CONCLUSION

This study estimates the mean basic reproduction  $R_0$  as 1.671 and Herd Immunity Threshold (HIT) is calculated as 40.16% by using past data. If once HIT has been reached through the vaccine, COVID gradually disappears and if it is achieved in worldwide, may result in eradication of the disease. This study concludes that vaccine-induced herd immunity helps us by playing a key role to eliminate this novel coronavirus.

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**Conflict of Interest:** No

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