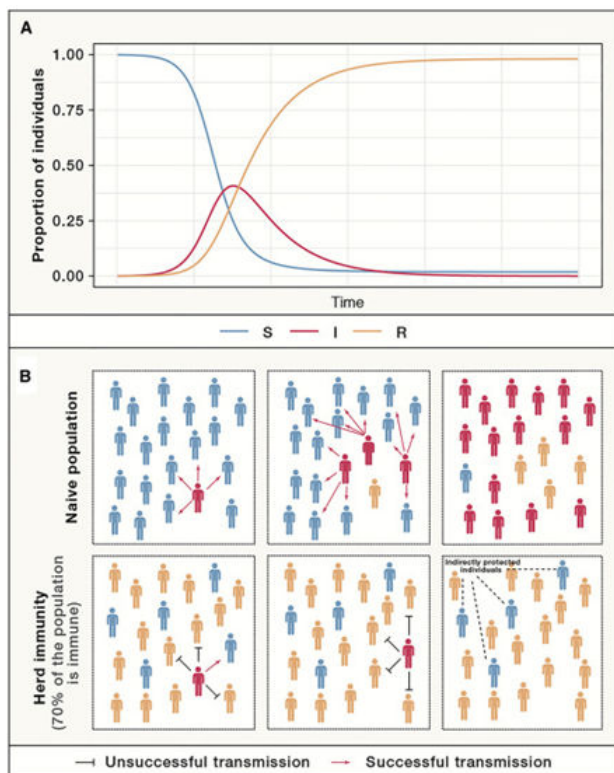






contact with a susceptible host. It can be achieved by either vaccination or by natural infection with the pathogen [23]. When an infected individual is introduced into the community various possibilities can occur, the most predicted one is that the pathogen will continue to multiply and spread to the susceptible host in the community in an unchecked manner, infecting them, if the host does not have any immunity against the pathogen. But if the same pathogen is introduced in a community where a proportion of people have immunity against the pathogen the spread or the transmission of the pathogen reduces and therefore less people are infected. So, if the predisposed individual in a population is reduced, if the hosts are immune to the pathogen, the pathogen cannot be transmitted and hence there is a decline in prevalence. Herd immunity threshold refers to a point at which the proportion of the susceptible individuals falls below the threshold needed for transmission [12]. Herd immunity becomes effective above this level of immunity and the individuals, who were earlier predisposed to get infected with the pathogen, are now at a much lower risk (Figure 1) [19].



**Figure 1: Herd immunity.**

## DISCUSSION

As discussed earlier the parameter determining the herd immunity threshold is  $R_0$  (the basic reproduction number). When an individual infected with the pathogen is introduced into a susceptible community spread of the disease occurs to the susceptible hosts, these are known as secondary infections and the average number of these secondary infections is taken as the  $R_0$  values. Suppose if the given value of  $R_0$  is 5, this implies that during an infectious period one infected host will result into spread

of the infection to 5 other people, (the assumption is that there is no immunity in the population under study). The herd immunity threshold determination is done by a mathematical formula  $1-1/R_0$ . (So if we take the value of  $R_0$  as 5, the herd immunity threshold comes out to be 0.8) [12]. With the above study we come to know that as the value of  $R_0$  increases the spread of the pathogen is larger and to stop this transmission a greater number of people need to be immune. Reproduction number is another important parameter to determine the level of immunity in a population denoted by  $R_e$  or  $R_t$ . The average number of secondary cases which occurred from a single index case over a specific infectious period in a partly immune population determines the value of  $R_e$  [9]. As  $R_0$  takes into consideration a completely susceptible population with no immunity while the  $R_e$  calculation is based on a population which is partly immune, the values of these two vary depending on the present immune status of the population, which changes when an outbreak occurs or when there is administration of mass vaccinations. The main goal of vaccination programs is to bring the value of  $R_e$  below 1 [19].

This value can be achieved only when the herd immunity threshold is exceeded by the population under study. With these levels the spread of the pathogen in the community is not maintained and there is decline in the number of individuals infected with the disease in the population.

## Establishment of herd immunity

The establishment of herd immunity depends on natural infection and vaccination. The main purpose of these should be to prevent the transmission of the disease along with the disease progress. After the attainment of herd immunity threshold, the strength and duration of the acquired immunity should be used to determine the efficacy. Clinical manifestations cannot be considered as an indicator of transmissibility as even asymptomatic hosts can be highly infectious and can be a contributing factor in disease progress and the epidemic spread. In certain diseases such as measles lifelong immunity is acquired, in such cases the effectiveness of herd immunity is high which can avert the spread of the pathogen. While in some other diseases such as rotavirus and pertussis, the immunity decreases with time. This leads to the decrease in effectiveness of the herd immunity and a possibility of outbreaks in future. The other factor that plays an important role is the evenly distribution of immunity in a population [19]. Suppose if the immunity is not evenly distributed and there is a cluster of population which is not immunized and they come in contact with other people, in that case these individuals can cause local outbreaks even if the immunized individuals in a population exceed the herd immunity threshold. The disease spread needs to be controlled at the local level which can be achieved by awareness among the public, health measures and the actions taken by community as a whole. Considering the above factors our next aim remains to undertake 1) Mass vaccination programs effectively and enrolling a large

number of people 2) Natural immunity of the population over time with the virus. Hence, although we aim at achieving herd immunity that would decline the disease progress we know that this is something which would take a lot of time with all the factors working together positively in a particular direction and would require the participation of health workers, government, the organisations working at both national and international levels, the administration, and most importantly the population under risk, the inputs by all these people will determine the output. For now the most that we can do is to follow all the norms such as social distancing, maintaining hygiene, usage of mask and hand sanitizers to combat the spread of the disease progress [18,24]. And special arrangements should be made to provide support to public health and medical systems (so as to reduce the burden on healthcare system).

### CONCLUSION

The development of vaccine remains to be the most important factor to control COVID-19 spread. But with the changing strains of the virus and the variations in the climatic conditions of various areas the task of attainment of herd immunity appears to be a difficult one/tedious and time consuming process. Once we reach a point at which a proportion of the population becomes immune which prevents the transmission of infection, there will be a decline in the number of affected cases, henceforth a decline in the outbreak. Therefore the most important factors which need to be taken care of include the population, the climatic variations and the level of the pre-existing immunity in the community. However such process takes time and a large number of people would be infected during this, a part of which will succumb to disease. The vulnerable group in the society should be given special attention. Along with providing the hospitals with more funds, making the availability of medications, oxygen cylinders easily available to the people along with cost effectively so that we don't lose any life due to unavailability of resources. Although we do not know the exact outcome that we will get after doing this entire procedure as there would be different constraints present at different levels that would hamper our outcome but for now as we do not have any other option that is strongly suggestive to limit the disease we go forward with the approach of herd immunity as it has benefited us in past and is expected to play a key role now as well. With all the resources put together and with people working together in a particular direction by following all the norms and guidelines, this difficult task can be attained. And for now this is the only hope left with us, in spite of the fact that we do not know the exact time that it would take or the exact level of effectiveness that would be present in an individual or a community as a whole. So with working on this together, meanwhile we need to follow all the safety guidelines so that the chain can be broken and we come back to our normal lives which for now appears to be far away but will definitely be possible in near future.

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