Critical interpretative synthesis of herd immunity for COVID-19 pandemic

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ABSTRACT

Introduction: Countries globally are evaluating the concept of herd immunity and its critical role in the control of pandemic. The current paper attempts to conduct a critical interpretative synthesis (CIS) on the role of herd immunity in current COVID-19 pandemic. **Methods:** CIS is tool for developing theoretical framework using interpretation drawn from relevant empirical and non-empirical sources. This review is done by formulating review question for literature search. Purposive sampling of literature was done followed by reciprocal translational analysis of extracted data. **Results:** Herd immunity is indirect protection from a contagious infectious disease when a population is immune either through vaccination or natural immunity developed through previous infection. The reproduction number for COVID-19 in India was found to be 2.56 and herd immunity threshold as 61%. **Discussion:** Exposing 71% young population in India to the SARS-CoV-2 infection can achieve herd immunity but with high morbidity as well as mortality. Vaccine are under process. Feco-oral transmission and reinfection of COVID 19 are major factors to develop or break the circle of herd immunity in community. "Immunity passport" can give false sense of security. Surveillance and seroprevalence studies assess immunity status, gradual exposure of infection to younger population and collaborative partnerships on organizations are few strategies to acquire herd immunity. **Conclusion:** Herd immunity is a measure for prevention and control of COVID-19 pandemic against the backdrop of mortality and morbidity. Vaccine can be boon but if herd immunity is to be acquired by natural infection then preparedness is necessary.

Keywords: COVID-19, herd immunity, reproductive number

Introduction

The pandemic of COVID-19 started as pneumonia of unknown origin on 19th December 2019 in Wuhan, China. On 30th January, WHO declared it as a Public Health Emergency of International Concern and within 2 weeks on 12th February 2020, WHO renamed the disease as COVID-19. In the course of seven months, COVID-19 infection was transmitted to 215 countries all over the world with more than 32 million confirmed cases (24th September 2020) and nearly death count heading towards 1 million.[1] India is contributing 17.76% in

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total cases of COVID 19 and struggling hard to contain the community transmission of the infection with case doubling rate of 46 days.[2-4]

India is a country with many challenges in the health care system. With one of the lowest GDP investments for health of 1.28%,[5] India's health care system is not capable to address the surge capacity of patients in COVID-19 pandemic. The technical, financial and human resources needed far exceed the current capacity of health care in the country. Hence, initial measures were focused on 'flattening the curve' for COVID-19 cases. As the pandemic evolved there was change in the focus of the pandemic where testing, contact tracing, isolation and treatment were prioritized.

Another major concern is the challenge in implementation of health promotion interventions for the control of COVID-19 along with their sustainability. Practice of frequent handwashing in India as per norms is challenged by the scarcity of water supply and absence of continuous running water in taps. Wearing of masks for prolonged periods is uncomfortable due to extreme weather conditions. Physical distancing is another challenge in Indian scenario due to culture of big families and high population density in urban areas and slums. Lockdown was initiated in India at the earliest with high stringency index from 24th March 2020[3] in order to prevent transmission of infection by keeping off crowd. But lockdown measures are not sustainable for developing economies like India with poor social support system for the underprivileged.

In this scenario, another available option to combat SARS-CoV-2 virus is herd immunity which can be either artificially acquired through vaccines or naturally acquired by getting exposed to the infection. Vaccines are still under development so countries globally are evaluating the concept of herd immunity and its critical role in the control of pandemic. The current paper attempts to conduct a critical interpretative synthesis (CIS) on the role of herd immunity in current COVID-19 pandemic. CIS is a tool for developing a theoretical framework using insights and interpretation drawn from a wide spectrum of relevant empirical and non-empirical sources.[4] Exhaustive review of this is needed with due importance given to media reports, interviews of experts and blogs to bridge the information gap in the limited time frame available.[6]

Methods

The Critical interpretative synthesis (CIS) method was used to review the literature and generate various themes for herd immunity. It was completed in the following steps:

Formulation of review question

The questions were framed for search of literature. A 360-degree review was done around the following questions
- Can herd immunity be used as one of the strategies to control the COVID-19 pandemic?
- What paradigms and approaches are used to achieve herd immunity?
- What are the challenges in acquiring herd immunity in India?

Literature search

Search engines like PubMed, EMBASE, Google scholar and Cochrane databases were used for peer-reviewed articles regarding the herd immunity. Blogs and interviews by subject experts were analyzed critically and only relevant matter to the review questions was included. International and National portals of health organizations, Census Commission of India and Ministry of Health and Family Welfare, Government of India were used to extract statistical data. Web search with Google was undertaken to identify the views of epidemiologists on herd immunity. The data regarding herd immunity and technical terms associated with it were retrieved using key words 'herd immunity', 'R0', 'COVID-19' and 'pandemic'.

Sampling

The number of articles considered for review were based on the inclusion criteria viz. content addressing the review questions along with study design. A purposive sampling technique was used until saturation of the content was observed.

Quality determination

Priority was given to the relevance of the topic for screening the articles, blogs and interviews rather than methodology or results. This was done purposefully so as to include maximum available content on herd immunity to contribute for the synthesis of theory.

Data extraction

Repetitive and thorough analysis of the retrieved data was done by highlighting the important concepts, making notes and adding notes and comments as and when required.

Conducting interpretative synthesis

Reciprocal translational analysis (RTA)[6,7] was used. The key metaphors, themes, or concepts in each study report were identified. An attempt was then made to understand the concepts. Similar concepts of different studies based on the themes were studied and analyzed and the concept that was 'most adequate' was chosen.[6]

Results

Initial review was done for 186 articles, blogs, newsletters, press notes, interviews of experts in the field of epidemiology and official websites of international and national health organizations, out of which 80 were selected on the basis of concept of CIS, herd immunity and reproduction number. The literature was again screened for the review questions mentioned in the methodology and finally 34 research articles, 5 interviews of subject experts, 9 blogs and data from 5 international and national official websites were used to form the themes. [Figure 1]

Definition of herd immunity

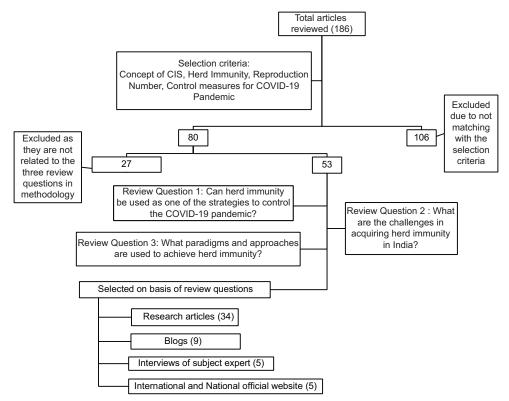Herd immunity is indirect protection from a contagious infectious

Figure 1: Flowchart showing selection of articles

disease that happens when a population is immune either through vaccination or immunity developed through previous infection.[8] Understanding herd immunity requires consideration of infection dynamics, modes of transmission, as well as the acquisition of immunity by individuals in the population.[9] Sustained transmission of any disease is prevented once the pathogenic organism is unable to find susceptible hosts because of isolation, quarantine, vaccination or natural immunity after exposure to infection. Isolation and quarantine open door for reinfection but vaccination or natural immunity after exposure leads to herd immunity offering protection in the long run.

Reproduction number (R0) and Herd Immunity threshold

The reproduction number (R0) is defined as the average number of new infections generated by one infected individual during the entire infectious period in a fully susceptible population. The basic reproduction number reflects the ability of infection to spread in the infectious period under no control.[10-12] R0 estimates were important in previous pandemics of H1N1 Influenza (2009) and SARS (2003). Similarly, effective reproduction number (Re) is defined as the average number of secondary cases generated by a single index case over an infectious periodin a partially immune population. The epidemiologists are focusing now on Re of SARS-CoV-2 which keeps on changing with the dynamics of unfolding pandemic as it is dependent on virulence of the infectious agent, susceptibility of the population for infection, demographics, socioeconomic factors and climatic changes.[13]

The approach used to estimate the basic reproduction number in the model is to calculate the average R0 based on the daily cumulative cases for 21 days described in equation 1.

The herd immunity threshold is estimated based on reproduction number by equation 2. Serial Interval (SI) is the time between onset of a primary and secondary case. Due to unavailability of detailed data on this parameter we have used SI as 4.4 days as reported in previous studies.[11,12] The herd immunity threshold basically indicates the resistance to the spread of an infectious disease within a population that results if a sufficiently high proportion of individuals are immune to the disease, especially through vaccination.[12]

$$Ro = [\Sigma exp \{logI\,(t)/(t/SI)\}] \div 21 \dots\dots\dots\dots\dots\dots\dots\dots$$
$$(Equation\ 1)$$

$$HI\ =\ [1\text{-}\ (1/Ro)]\ X\ 100\ \dots\dots\dots\dots\dots\dots\dots\dots\dots$$
$$(Equation\ 2)$$

The reproduction number for COVID-19 in India was found to be 2.56 and herd immunity threshold as 61%.[12]

Herd immunity as a preventive tool for infections

Herd immunity as a protective tool against infectious diseases differs according to R0 (Reproduction number explained before). Some of the infectious diseases showing protection with herd immunity are described below:

Measles

R0 for measles is 12-18, which means that each person with measles on average will infect 12–18 other people in a susceptible population.[14] Thus target coverage of measles vaccination is to cover at least 95% population for herd immunity.[14-16]

Mumps

Mumps has R0 of 10-12. Thus, for mumps, the herd immunity threshold of 92% is required for the population to be immune to stop disease transmission.[17]

Swine flu (H1N1)

By the time WHO declared a pandemic of Swine Flu in June 2009, 74 countries had reported laboratory confirmed infections.[18] People in Norway successfully developed partial herd immunity to H1N1 virus through vaccinations and natural immunity. Thus H1N1 swine flu has produced antibodies that are protective against variety of flu strains making later outbreaks less severe.[19-21]

COVID-19 on Diamond princess Cruise

Diamond Princess Cruise ship, with 3711 people on board experienced an outbreak of COVID-19. The median R0 of COVID-19 was 2.28 (95% CI of 2.06–2.52) during the early stage.[22] In spite of R0 being 2.28 out of total 3711 people on board 712 (19.18%) were symptomatic patients and 331 (8.9%) were asymptomatic but tested positive for COVID 19.[22] Rest of the 72% population on the ship remained unaffected even after being exposed to the infection. Diamond princess being a 'natural cohort' can be an example of herd immunity which is to be acquired in case of COVID-19.

Discussion

Anticipating herd immunity in India for COVID 19 pandemic

As per the Census data of India 2011, 84.5% population is from the age group of 5 to 65 years. So even if the vulnerable population is left i.e., less than 5 years (10.7%) and more than 65 years (4.8%),[23] then as per equation 2, herd immunity threshold of 61% can be easily achieved in India by exposing rest of the population and also excluding people with comorbities. Currently (as on 23rd September 2020) it is seen that 4106 per million population are affected by COVID-19 with 125 deaths per million population.[24] A huge chunk of population is yet to be to be exposed to achieve the target of herd immunity. Probably at this juncture herd immunity needs a careful review on its applicability in controlling the current pandemic.

Primary care physicians play an important role in generation of awareness of herd immunity among population being the first point of contacts for the patients. Early diagnosis by testing asymptomatic patients as well and treatment is integral part of curbing the pandemic in which primary care physicians are an important link.

Challenges in achieving herd immunity

Only 2.14% of Americans had been infected even after having highest number of cases globally. Population-weighted seroprevalence after adjusting for test performance was 0.73% in India.[25] So, countries are far away from achieving herd immunity threshold of 61% immune population.

However, natural herd immunity, achieved through infection rather than vaccination, can be challenging due to high rate of serious illness and death, with health systems overwhelmed well beyond their surge capacity, even in high-income countries.[8] In countries like India with high population density, exposing population to COVID-19 infection in order to acquire herd immunity may prove disastrous and fatal .

Infection fatality rate (IFR) is an important measure to assess the societal cost of achieving global herd immunity. The IFR is defined as the proportion of deaths caused by a certain disease among all infected individuals. Due to asymptomatic cases along with diagnosed cases in infected individuals, the IFR will inherently be lower than the case fatality rate which includes only confirmed cases.[13]

Out of all infected patients, 5% are critically ill with severe lung dysfunction, shock or extra-pulmonary organ failure and needs hospitalization and ventilation.[26, 27] In the scenario to achieve herd immunity, if 60% of population is exposed to infection then enormous number of people will be very sick, which has huge implications for the country as well as strain for the already overburdened health care settings.

Even when vaccines are available, it is not always possible to achieve herd immunity for very long. In case of SARS-CoV-2 virus, which is seen mutating frequently, will need regular updated vaccines to maintain the immune status which can be expensive in terms of procurement, research and development.

Feco-oral transmission of COVID 19 is another aspect under development. Study of the enteric involvement and viral excretion of SARS-CoV-2 in feces is required to investigate whether fecal concentrations of SARS-CoV-2 RNA correlate with the severity of the disease and presence or absence of gastrointestinal symptoms, and whether fecal SARS-CoV-2 RNA can also be detected in the incubation or convalescence phases of COVID-19.[28] This is going to be major factor to develop or break the circle of herd immunity in community.

The World Health Organization and South Korea are investigating about reinfection of SARS-CoV-2 virus. The possible reasons for this were stated as variable immune response of the patient, re-exposure to new strain of virus or false positive test results.[29] Thus, reinfection can be major factor to prevent the development of herd immunity.

When a population does not reach the required herd immunity threshold then the overall immunity level is compromised and herd immunity can be lost, putting everyone at risk of the disease.[8] In the study done by Wu *et al.* in COVID 19 patients, it was found that formation of neutralizing antibodies against SARS-CoV-2 is very common but longitudinal serological studies will be required to measure the duration of effectiveness of antibodies.[13] So far, there is not enough evidence about the effectiveness of antibody-mediated immunity to guarantee the accuracy of an "immunity passport" or "risk-free certificate" for the people to travel or declare as protected against infection and return to their jobs. People once seropositive for COVID-19 may ignore public health advice. The use of such certificates may therefore, increase the risks of continued transmission.[30]

Researchers, policymakers and public health advocates can consider herd immunity as an option while planning their post-lockdown strategies to deal with the pandemic but in consideration with that other health promotional measures like handwashing, usage of masks and physical distancing are being followed by the population.

Strategies to acquire herd immunity

- Fever and Influenza like illness surveillance in the community on a regular basis accompanied with meticulous data monitoring is necessary to evaluate the population exposed to the infection. This will help in estimation of the time required for development of herd immunity.
- Longitudinal serosurveys should be done to assess the immune status of the population for SARS-CoV-2 virus in high and low transmission zones.[25]
- Multi-pronged area-specific strategy should be made towards the exit plan from this pandemic moving further to achieve herd immunity.
- Geographically tailored approach should be used in opening of social life with consideration of basic health promotion measures like handwashing and physical distancing.
- In order to achieve the protective level of the immunity, gradual exposure of infection can be strategically planned by exposing young healthy individuals first followed by children and geriatric population. This can be done initially by reopening of schools and colleges followed by restarting industries, agricultural activities, gradually resuming international travel. On the other hand, simultaneously, exposed population will be recovering from the infection.
- The general population should be made aware of the concept of reverse quarantine. Reverse quarantine is isolation of the vulnerable population from the virus. Vulnerable population for COVID-19 infection includes elderly, people with existing co-morbidity, immunocompromised individuals and children less than 10 years.[31] All of them should be isolated from those going out in community during the pandemic by decreasing interactions and visits. Preventive measures like physical distancing, hand hygiene and psychological counselling should be followed in order to take care of the

physical and mental health of the vulnerable under reverse quarantine.
- Correct information related to the disease should be circulated among the population including concept of herd immunity. Prevention from infodemics will enable people to fight against the disease in right way.
- Promoting partnership comprising of organizations having common goals and objectives and that combine resources is needed to implement research for vaccine development. Partnerships can reduce duplicity of efforts, ensure synergy of resources, and augment the overall leadership within the country.

Conclusion

Herd immunity is a measure for prevention and control of COVID-19 pandemic against the backdrop of mortality and morbidity with huge burden on the health care system. If the herd immunity is to be acquired naturally by exposing at least 60% of 5–65 years (84.5%) of population to SARS-CoV-2 infection, then preparedness is necessary in terms of health care facilities with economic implications. Focus is needed on research aiming at appropriate strategies,identification of challenges and approaches to acquire herd immunity along with development of vaccine.[32-43] Testing, treatment, tracing, teamwork and tracking with monitoring and surveillance are the tools to measure time required to acquire herd immunity to contain the COVID-19 pandemic and associated multifaceted implications in global and Indian context.

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Conflicts of interest

There are no conflicts of interest.

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