Global Health

An analysis of the role of herd immunity in combating SARS-CoV-2

Ihsan Imran, *Australia*

Abstract

In recent times, there has been an unprecedented rise in the use of the medical jargon term 'herd immunity' among the public, primarily due to media and news reporting in the current pandemic. The concept of herd immunity has often been misquoted and misinterpreted, leading to significant and, at times, fatal outcomes. The objective of this study is to critically analyse the public perception of 'herd immunity' and, upon evidence-based research, either validate or disprove these claims. In light of the present severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic, an understanding of the implications of vaccinations for developing herd immunity is crucial. In the past, vaccinations have had a critical function in minimising the spread of infectious pathogens and protecting communities from devastating consequences .

Keywords: herd immunity, pandemic, coronavirus, vaccinations

Introduction

Herd immunity refers to an indirect means of protection for vulnerable individuals that are unable to be vaccinated against a specific pathogen, when a sufficient proportion of the rest of the population is immunised. Alternatively, herd immunity may refer to the threshold proportion of immunised individuals required to limit the incidence of infection[1]. Herd immunity is based on the inability of a pathogen such as SARS-CoV-2 to infect and spread within a population due to a lack of susceptible hosts. The novel severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), an obligatory intracellular viral pathogen, is the causative agent of Coronavirus Disease 19 (COVID-19) and is responsible for the current pandemic. The term 'herd immunity',

first coined in 1923 by Topley and Wilson[2], only began to be used widely due to increased immunisation programs and campaigns working towards global disease eradication.

The concept of herd immunity and why it matters

Herd immunity is a control measure that ensures large outbreaks of infection in a specific geographical region does not occur. This form of immunity involves a population rather than an individual; hence the term 'herd' is used referring to a group of people. Herd immunity can be achieved via natural infections or artificially acquired immunity by vaccinations. The proportion of individuals in a population required to attain herd immunity is dependent on the reproductive number (R) of the pathogen – how contagious a pathogen is[3]. The reproductive number (R) for SARS-CoV-2 in the UK is estimated to be between 0.9 and 1.04. Furthermore, any intervention measures practiced lower the herd immunity threshold and, therefore, the probability of mass outbreaks. These measures include personal hygiene, social distancing, isolation, mask wearing, ventilation and lockdowns. Herd immunity provides a source of protection for the unvaccinated individuals, as the likelihood of contact with an infected person is minimised, refer to Figure 1. An understanding of herd immunity is vital to determine the current level of herd immunity present in a population, the level of herd immunity necessary and if control measures are required. That must, then, be compared to the economic, physical and psychological cost of this endeavour. The central dogma of herd immunity states that the higher the proportion of the population that is immunised, the lower the chances of a sustained chain of infection occurring. In order for herd immunity to be effective, not only must immunisation prevent the onset of symptoms, it must also prevent transmission of the pathogen, particularly with SARS-CoV-2,which has many asymptomatic carriers. With the incubation period of SARS-CoV-2 varying from 1 to 14 days, the coronavirus-2 can be transmitted to susceptible individuals despite the infected person not showing signs or symptoms.[5,6]

Infection	R_0	Herd immunity level
Diphtheria	6-7	83-85%
Measles	12-18	92-94%
Mumps	4-7	75-86%
Pertussis	5-17	80-94%
Rubella	6-7	83-85%
Smallpox	5-7	80-85%

Table 1: The R0 and Herd immunity threshold of common-vaccine preventable diseases.

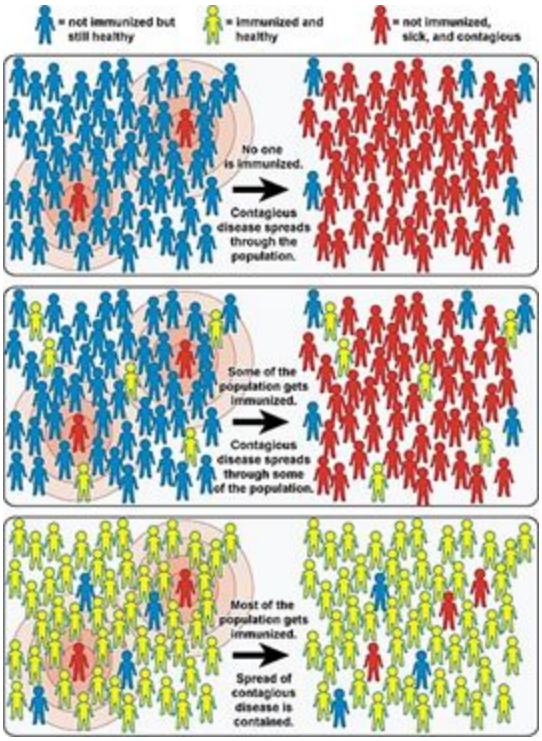

Figure 1: A diagrammatic view of the outcome of herd immunity when different proportions of the population is immunised against a disease. The higher the proportion of the population that is immunised, the lower the rate of infection within the population is, therefore, protecting community members. Credit: National Institutes of Health (NIH)

Early estimates of the herd immunity threshold for COVID-19 placed it at ~43%[7], much lower than the threshold required for other infectious diseases, refer to Table 1[8]. However, this estimation may vary between countries due to a number of variables. A crucial statement mentioned in this study is that "if nonpharmaceutical interventions are very strict, no herd immunity is achieved, and infections will then resurge if they are eased too quickly." The implications of this will be further discussed in the case study comparison of Australia and Sweden's pandemic control policies.

Naturally acquired vs artificially acquired herd immunity

In order to acquire herd immunity, individuals must first obtain immunity either via the natural process of becoming infected or via vaccinations. Natural infection and vaccinations both offer active protection against a specific pathogen through specific antibody production and the generation of memory B cells that provide immunological memory in the event a person is re-exposed to the identical pathogen. Acquiring herd immunity via the natural process of infection

results in societal consequences. Case fatality rate (CFR) is a key measure used by epidemiologists to identify the costs associated with developing herd immunity in the absence of vaccinations. CFR refers to the proportion of deaths to the number of infections.[5] However, the CFR value for COVID-19 has varied as the pandemic has progressed. It differs between geographical regions. The heterogeneity of the CFR value may be due to a myriad of factors, including "comorbidity risks and demographic, economic and political variables".[10] Attempting to achieve herd immunity through natural infection fails to consider the finite capacity of health care systems, resulting in over hospitalisations and, additionally, this policy disregards the ethical consideration of the value of human life. Increased hospitalisations due to COVID-19, has resulted in a decrease in non-COVID-19 hospitalisations in the United States, impeding patients' access to health care services and, in turn, causing poor health outcomes.[11] Conversely, attaining herd immunity through mass vaccinations mitigates the onset of disease, protecting the vulnerable and reducing the CFR value, thus proving to be a more effective means of controlling outbreaks. However, mass vaccination programs are dependent upon the availability of clinically proven effectual vaccines. A vaccination traditionally can be a suspension of an attenuated virus or pathogen containing pathogenic antigens that stimulates an immune response, resulting in the production of specific antibodies that are complementary in shape to the viral antigens and memory B cells clonal selection and clonal expansion that occurs simultaneously. Other forms of modern vaccinations include an mRNA-based vaccine such as the Pfizer-Biotech vaccine that has been proven to be 95% effective against COVID-1912 or the AstraZeneca viral vector vaccine with an efficacy of 90%.13

Generating herd immunity against SARS-CoV-2

Herd immunity is developed from the combination of mass vaccinations and other preventive measures including lockdowns, mask wearing and 1.5 m distancing that most governments globally have made mandatory in the event of COVID-19. The common misunderstanding of the public arises here, where some advocate for the abolition of lockdown measures that have been put in place relying on the reasoning that natural infection via first hand exposure will pave a path towards building herd immunity within a community. A prime example being the Great Barrington Declaration that asserts "the damaging physical and mental health impacts of the prevailing COVID-19 policies"[14] and instead requests for "focused protection"[14] that shelters the vulnerable, while concurrently preventing the deleterious impacts on education. However, in contrast to these unfounded claims, Figure 2[15] shows the epidemiology of COVID-19 in a number of countries pre-lockdown and post-lockdown in terms of the number of cases per million people. Figure 2 shows a second peak in daily cases during the months of September to November. The second lockdown in the UK introduced on the 5th of November 2020 resulted in a precipitous

decline in daily confirmed COVID-19 cases. Similarly other European countries including France, Italy, Czech Republic, Spain have imposed further strict restriction protocols and lockdowns as they face the 'second wave' of COVID-19 cases.

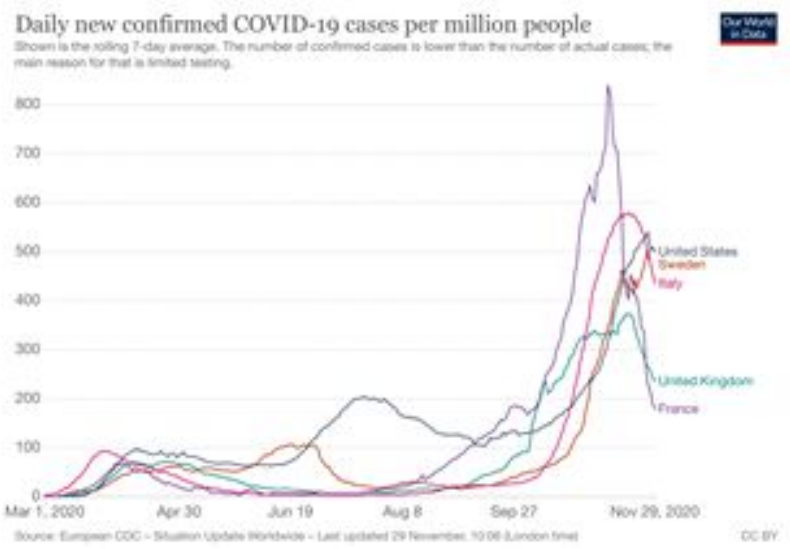

Figure 2: The daily number of confirmed COVID-19 cases per million people in countries, including the United States, Sweden, Italy, United Kingdom and France. [14]

Case Study: Epidemiology of COVID-19 in Sweden and Australia

This case study seeks to analyse the differences in strategies employed by Sweden and Australia and the outcome of each strategy in order to determine their efficacy. Sweden has a population of 10.1 million and a population density of 25 people per km^2 of land area[16], whereas Australia has a population of 25.2 million and a population density of 3 people per km^2 of land area on average, however this difference is disregarded as major metropolitan areas on average have a population density upwards of 25 people per km^2.[17] Sweden has chosen the unconventional method of relying upon 'herd immunity' by permitting voluntary measures on the part of its citizens, whilst not imposing strict regulations. Sweden has seen no lockdowns, whereas Australia has, instead, enforced mandatory protective measures, including curfews, lockdowns as daily cases rose, and the outcomes of both Australia and Sweden's policies are reflected in Figures 3 and 4, respectively.[14]

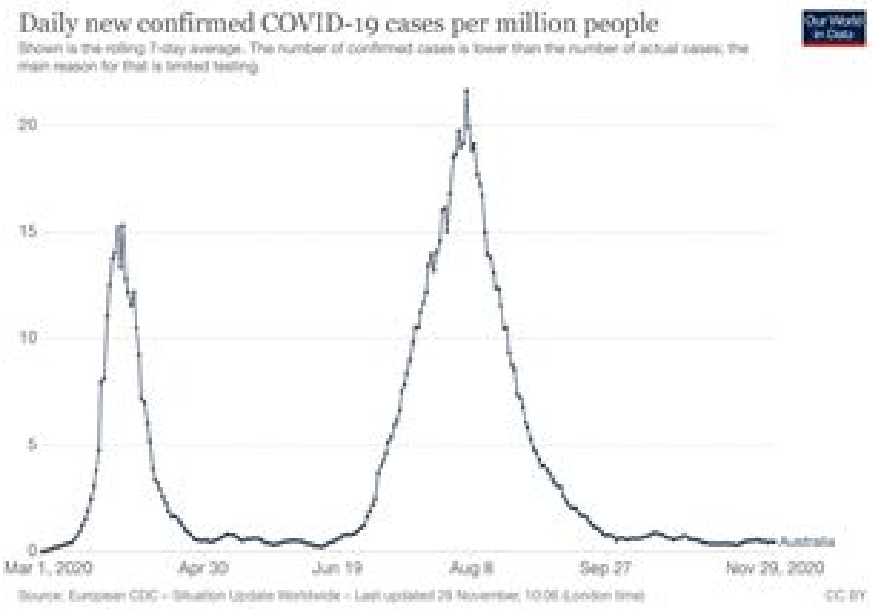

Figure 3: The daily number of confirmed COVID-19 cases per million people in Australia.[14]

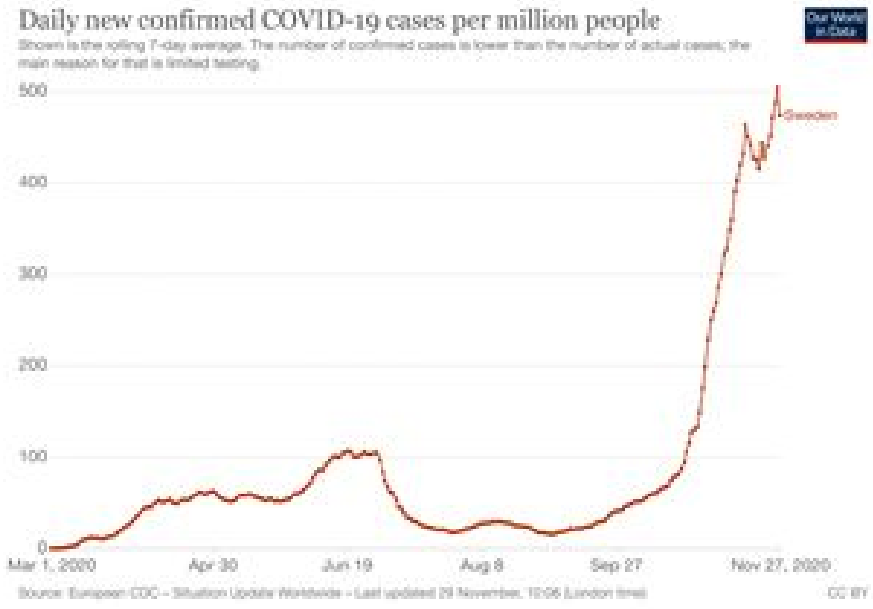

Figure 4: The daily number of confirmed COVID-19 cases per million people in Sweden.[14]

There are two significant peaks in Figure 3 (Australia), that indicate outbreaks from March to April and from June to September at 15.32 and 21.64 daily cases per million people, respectively. Each peak in daily cases was followed by strict lockdown measures that resulted in a dramatic

decrease in daily cases, supporting the efficacy of introducing lockdowns that reduced the transmission of SARS-CoV-2, with a current daily case average of 0.44 per million in Australia. Sweden, instead, is experiencing a surge in cases with approximately 473.34 daily cases per million people. This ruinous outcome is primarily due to the lack of initial safe preventive strategies including lockdowns. The Swedish strategy similar in practice to the Great Barrington Declaration seeks to protect the vulnerable whilst allowing the infection rates amongst other to rise to develop 'herd immunity'. Reasons for the Swedish adopting this strategy includes the concern of whether lockdown procedures would translate into an economic downturn alongside the impacts on non-COVID related health issues.[18] However, a fine balance between a series of lockdowns is required for a successful turnout as observed in Figure 3. Relying solely upon theoretical 'herd immunity' is an ineffective and precarious policy amidst the current pandemic.

Conclusion

Coronavirus disease 19 (COVID-19) caused by SARS-CoV-2, an infectious agent is responsible for the current pandemic. In light of the past 11 months, different strategies have emerged intended to control and minimise its deleterious health impacts upon individuals. An often-cited term, 'herd immunity' describes the level of immunity required in a population to prevent outbreaks of disease. However, herd immunity is not a policy or preventive method that should be relied upon primarily, as the societal expense, in terms of fatality rates, daily record high cases and excess hospitalisation that places non-COVID related health issues at risk, is substantial. Therefore, preventive measures such as social distancing, mask wearing, lockdowns, ventilation, isolation are imperative strategies that must be employed for the foreseeable future until immunisation programs for COVID-19 are available globally.

For references, footnotes and endnotes, click here.