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Will We Be Able to Achieve Herd Immunity Against COVID-19?

Series | COVID-19 & response strategy

ISGlobal Barcelona Institute for Global Health

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[This document is a one of a series of discussion notes addressing fundamental questions about the COVID-19 crisis and response strategies. These documents are based on the best scientific information available and may be updated as new information comes to light.]

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On 10 May 2021, the Spanish prime minister announced that, if the vaccine delivery schedule is met, Spain would reach the government's desired level of herd immunity—70% of the population vaccinated—in 100 days, i.e. on **18 August**[1]. Given the available evidence, is this claim **realistic**?

Since COVID-19 was declared a pandemic in March 2020, our societies have undergone profound changes, starting with government-imposed restrictions on fundamental rights such as freedom of movement and freedom of assembly. An **effective vaccine** against SARS-CoV-2 was seen as the **great hope** for a way out of the health and economic crisis caused by COVID-19 and **attention soon turned to the question of herd immunity**.

The World Health Organisation (WHO) defines herd immunity as "the **indirect protection** from an infectious disease that happens when a population is immune either through vaccination or immunity developed through previous infection"[2]. Since the start of the pandemic, the possibility of achieving **herd immunity** has been touted as a way to avoid shutting down the economy or accelerate its re-opening. However, this proved to be a **double-edged sword**. Countries such as **Sweden** and the **United Kingdom** tried to base their strategy on achieving early herd immunity by allowing a majority of the population to become infected. These strategies were either rectified, as in the United Kingdom, or mortality increased to an unjustifiable extent, as in Sweden. Today, with the availability of highly effective vaccines and an unprecedented vaccination campaign, herd immunity is once

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1 Jessica Mouzo. Sánchez asegura que España está "a 100 días de lograr la inmunidad de grupo". *El País*. 10 May 2021.

2 World Health Organisation (WHO). Herd immunity, lockdowns and COVID-19.

again the great hope for countries to regain some semblance of normality.

In reality, **there is no magic immunisation rate** that provides herd immunity against any pathogen; instead, it depends on the characteristics of each micro-organism. In the case of SARS-CoV-2, the herd-immunity threshold is not yet known, and some of the key questions raised by this objective are worth addressing

1. What Percentage of the Population Must Be Vaccinated to Achieve Herd Immunity?

"Because the basic reproduction number of SARS-CoV-2 is an estimate and we do not know for sure how it responds to factors such as space or different variants of the virus, we cannot accurately calculate the vaccination rate needed to reach herd immunity."

First, it is important to note that the **herd-immunity threshold is not known with any certainty**, because it is based on the virus's **basic reproduction number** or R_0 (the average number of cases that will be caused by an infected individual during the period of infection). Because the R_0 of SARS-CoV-2 is an **estimate** and we do not know for sure how it responds to factors such as space or different variants of the virus, we cannot accurately calculate the vaccination rate needed to reach herd immunity. Any estimate is just that: an approximation that we currently have no way of testing.

In the early days of the pandemic, the WHO[3] and other experts estimated that 60%-70% of the population needed to be immune in order to achieve herd immunity. This estimate was based on information from early outbreaks in China and Italy. As the number of cases in those outbreaks doubled rapidly, it was calculated that the R_0 for this virus—i.e. the number of new victims infected by each carrier—was approximately three. Therefore, two out of every three potential victims would have to become immune before the number of people infected by each carrier could fall below one. **When each carrier infects less than one new person, an outbreak slowly fades away**. Two out of three is 66.7%; hence the **60%-70%** range for herd immunity[4].

However, several **factors have caused the scientific community to raise doubts about this range**. First, the data from China did not include **asymptomatic patients** and therefore underestimated the R_0 of the virus. Second, the virus itself is mutating and some of the **variants** that have emerged are more contagious; this changes the R_0, and thus the range for herd immunity. In an interview with the *New York Times*, researchers at the Harvard School of Public Health estimated that the **threshold could be 85% or higher**[5]. The Centers for Disease Control and Prevention (CDC)[6] have not offered an estimate; their website states only that we are still learning how many people need to be vaccinated before herd immunity takes hold. The same is true of the website for the European Centre for Disease Prevention and Control (ECDC)[7].

In addition to the **percentage of vaccination coverage**, we should also be con-

[3] World Health Organisation (WHO). Herd Immunity.

[4,5] Donald G. McNeil Jr. How Much Herd Immunity Is Enough? *New York Times*. Published December 2020, Updated April 2021.

[6] Centers for Disease Control and Prevention (CDC). Key Things to Know About COVID-19 Vaccines.

[7] European Centre for Disease Prevention and Control (ECDC). Questions and answers on COVID-19: Vaccines.

cerned about whether **immunisation is evenly distributed**. If, for example, the vaccination coverage rate is 90% in one **geographical area** and 60% in another, the overall vaccination rate will not reflect the reality, which is that people in the latter area are much more exposed than those in the first. The same is true of different populations, such as people with irregular migration status[8] or other **groups** at risk of social exclusion. In addition to monitoring the overall proportion of vaccinated people in the **population**, we need to be aware of how access to the vaccine is distributed. Moreover, some populations, such as children, are **not yet vaccinated**, and others, such as immunocompromised people, **generate suboptimal immunity**—or do not do not generate immunity at all—even if they are vaccinated. Therefore, the vaccination coverage rate in the immunocompetent adult population needs to be higher in order to compensate for this.

It is worth noting that the critical vaccination level varies depending on whether the goal is to achieve disease elimination rates, as with polio or measles, or to achieve sufficient vaccination coverage to aid in effective disease control, as with influenza or pertussis. The latter approach is often taken with infections for which we do not have highly effective vaccines to stop transmission or when there are pockets of vulnerable populations. In the case of SARS-CoV-2, **it is not yet clear whether we will fully eliminate the disease or achieve only functional control of the pandemic** (preventing hospitalisations and deaths through vaccines and possibly future treatments).

If we take the **example of measles**—the most contagious vaccine-preventable infectious disease—95% of the population needs to be vaccinated in order to achieve elimination. Since SARS-CoV-2 has been shown to be less contagious than measles, we can set an upper bound on the percentage of the population that needs to be vaccinated (assuming a strategy of elimination, not just functional control), but the lower bound is not yet known ●

[8] José Domínguez. Osakidetza inmunizará a la población extranjera irregular. *El Correo*. 1 June 2021.

Table 1. Critical immunisation rates.

Percentage of the population that must be vaccinated in order to create herd immunity against various diseases.

The percentage is related to the contagiousness of the micro-organism, which in turn is related to the infectivity of the pathogen, transmission route, host susceptibility and immunogenicity (for example, vaccines are generally less immunogenic in older people), as well as environmental factors such as solar radiation and socio-economic determinants.

Disease	Vaccine efficacy (vaccines marketed in Spain)[9]	Critical vaccination threshold for herd immunity[10,11]	Main mechanism of transmission	Public health approach
Measles	One dose 93%, two doses 100%	92%-96%	Airborne and contact	Elimination
Rubella	One dose 93%, two doses 100%	84%-88%	Respiratory droplets and vertical transmission	Elimination (mainly congenital rubella)
Mumps	One dose 78%, two doses 88%	88%-92%	Respiratory droplets and contact	Effective control
Pertussis	Acellular vaccine 85%	92%-96%	Respiratory droplets and contact	Effective control
Polio	Three doses 99%-100%, parenteral inactivated poliovirus vaccine (IPV)	80%-85%	Faecal-oral and pharyngeal secretions	Elimination and global eradication
Seasonal influenza	70%-80% depending on the circulating virus	N/A	Respiratory droplets and airborne under certain circumstances	Protection of the most exposed and vulnerable groups
COVID-19	94% Moderna 95% Pfizer 76% AstraZeneca 66% Janssen [12]	To be determined	Respiratory droplets and airborne under certain circumstances	To be determined

N/A (not applicable): This vaccine is not included in the childhood immunisation schedule and is not administered at the population level; herd immunity is not the objective.

[9] Spanish Vaccinology Association. Vacuna a vacuna.

[10] Roy M. Anderson, Robert M. May. Vaccination and herd immunity to infectious diseases. Vol. 318. *Nature*. 28 November 1985.

[11] Oxford Vaccine Group. Herd Immunity: How does it work?.

[12] ISGlobal. FAQs on COVID-19 Vaccines.

2. What Are the Obstacles to Achieving Herd Immunity?

"If vaccinated individuals can still become infected and infect others at a significant rate, vaccines will not have such an appreciable effect on herd immunity."

The immunisation rate necessary to achieve herd immunity is not the only subject of debate. Within the scientific community, there is no consensus on the question of whether or not herd immunity can, in fact, be attained. Several obstacles[13] have been identified. First, although vaccines have been shown to reduce transmission, the available evidence[14] suggests that they do not stop **transmission** completely, which could make achieving herd immunity more difficult. If vaccinated individuals can still become infected and infect others at a significant rate, vaccines will not have such an appreciable effect on herd immunity. Moreover, the spatial heterogeneity[15] of the disease must be taken into account. Transmission rates vary by region and change over time, affecting vaccine efficacy. Assuming a homogenous transmission rate and a vaccine that is less than 80% effective at stopping transmission, the entire population[16] would have to be immunised in order to achieve herd immunity.

Second, **global vaccine distribution is completely heterogeneous**: while countries such as Israel have already vaccinated more than half of their population, vaccine coverage remains anecdotal in most low- and middle-income countries. In a globalised world without hermetically sealed territories, and with justified fears of further border closures, herd immunity cannot be guaranteed for anyone unless a global health strategy is adopted.

Third, more transmissible **variants of the virus** have emerged, pushing up the vaccination threshold required for group protection. As immunity rates rise, selective pressure also increases, favouring the spread of more contagious variants. All this is coupled with the fact that we do not know **how long immunity lasts**. Therefore, when the last population groups are finally vaccinated, we cannot be sure that the first groups to be immunised will still have antibodies against the virus. Another factor to bear in mind is that vaccines can **change people's behaviour**, causing them to be more exposed. These behavioural changes can have an effect on R0 and send us back to square one

[13] Christie Aschwanden. Five reasons why COVID herd immunity is probably impossible. *Nature*. 18 March 2021.

[14] Ross J Harris; Jennifer A Hall; Asad Zaidi; Nick J Andrews; J Kevin Dunbar; Gavin Dabrera, Impact of vaccination on household transmission of SARS-COV-2 in England. Preprint.

[15] Robert M. May, Roy M. Anderson. Spatial heterogeneity and the design of immunization programs. *Mathematical Biosciences*. Volume 72, Issue 1, November 1984, Pages 83-111.

[16] Roy M Anderson, Carolin Vegvari, James Truscott, Benjamin S Collyer. Challenges in creating herd immunity to SARS-CoV-2 infection by mass vaccination. *The Lancet*. Volume 396, Issue 10263, P1614-1616, 21 November 2020.

3. What Is Happening in Other Countries?

"The case of Chile demonstrates that non-pharmacological measures are crucial and that we must not rely solely on vaccination rates."

The experience of other countries outside the European Union can provide valuable information about what strategy should be followed. The following are some key examples:

a. Countries with high vaccination coverage

• **Israel**: By April, an estimated 68%[17] of the population was immunised, including both vaccinated individuals and people who have been infected with the virus. Cases of COVID-19 continue to fall[18], suggesting that the country may indeed be close to achieving herd immunity. What factors have helped to achieve this? First, Israel used a highly effective vaccine (early studies suggest more than 95% efficacy at preventing infection). Second, the country is small, both geographically and in terms of population. Third, Israel has advanced information technology that facilitated the prioritisation, allocation and documentation of vaccines for eligible individuals. Moreover, there was effective cooperation between the government and community health centres, which were responsible for providing vaccines to recipients. Finally, Israel has extensive experience in large-scale rapid emergency response.

• **Chile**: Despite being among the countries with the highest rates of vaccination coverage, Chile has reached the highest rate of infection since the worst moment of the pandemic[19] and critical-care occupancy is at 95%, on par with the darkest days of the first wave. Why? First, poor traceability and low rates of adherence to restrictions: the high rate of informal employment, especially in the poorest areas, coupled with socio-economic inequalities, has meant that people have had to go out to work despite the restrictions on mobility[20]. Moreover, internal mobility within the country has been high—nearly three million holiday permits, authorising travel between regions of Chile, were granted in January and February—leading to a rapid rise in cases[21]. Finally, the vaccine used most widely in Chile, Sinovac, is 67% effective at blocking transmission, according to most studiess[22]. In other words, it does not completely stop transmission and therefore, on its own, it is not enough to control the pandemic, at least until a higher percentage of the population is immunised. The case of Chile demonstrates that non-pharmacological measures are crucial and that we must not rely solely on vaccination rates.

b. Countries with low vaccination coverage

• **India**: With 3.2% of its population vaccinated[23] India is facing a health crisis that is overwhelming all of its institutions. As a second wave[24] sweeps across the country, deaths have risen significantly in recent weeks, making India the global epicentre of the pandemic. The so-called "Indian variant" is also having consequences outside of the country, causing cases to rise in Vietnam and the United Kingdom.

• **Vietnam**: Despite being one of the most successful countries in containing the pandemic in 2020, Vietnam—where only 0.03%[25] of the population has received two doses of vaccine—is currently seeing an alarming increase in cases that

[17] Rachel Schraer. Covid: 'Israel may be reaching herd immunity'. *BBC*, 14 April 2021.

[18] Eyal Leshem, Annelies Wilder-Smith. COVID-19 vaccine impact in Israel and a way out of the pandemic. *The Lancet*. Volume 397, Issue 10287, P1783-1785, 15 May 2021.

[19] Chilean Government. Official COVID-19 figures.

[20] Lioman Lima. Coronavirus en Chile: cómo se explica que pese a la buena vacunación tenga la tasa de contagio más alta desde el peor momento de la pandemia. *BBC*. 11 March 2021.

[21] Pascale Bonnefoy, Ernesto Londoño. Despite Chile's Speedy Covid-19 Vaccination Drive, Cases Soar. *The New York Times*. Published March 30, 2021. Updated April 16 2021.

[22] World Health Organisation (WHO). Evidence Assessment: Sinovac/CoronaVac COVID-19 vaccine.

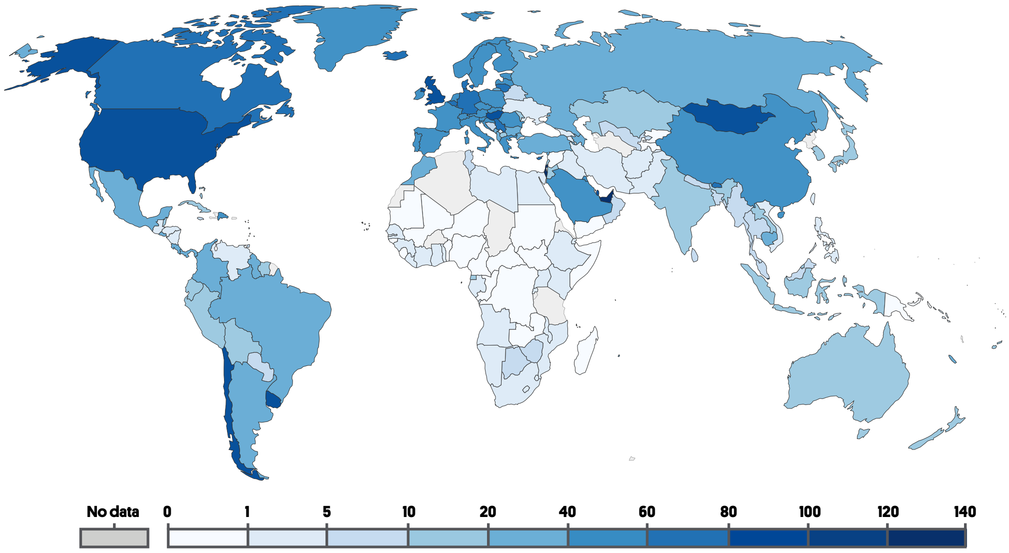
[23] Covid-19 vaccine tracker: the global race to vaccinate. *Financial Times*.

[24] Coronavirus en India: decenas de cadáveres más aparecen en el río Ganges. *BBC*. 11 May 2021.

[25] Covid-19 vaccine tracker: the global race to vaccinate. *Financial Times*.

is overburdening the country's health services[26]. As the epidemiological situation has worsened, Vietnam has implemented various restrictions, including the closure of all non-essential services.

Figure 1. Vaccine doses administered per 100 people.



Source: Our world in data. Coronavirus (COVID-19) Vaccinations.

Figure 2. Rates of full vaccination in different countries as of 2 June 2021.

Israel: 56,7%
Bahrain : 48,2%
Malta: 41,9%
Mongolia: 40,5%
United Kingdom: 38,5%
Chile: 41,9%

Philippines: 1,1%
Pakistan: 0,7%
Afghanistan: 0,3%
Sierra Leone: 0,1%
Cameroon: 0,05%
Benin: 0,004%

Spain: 19,6%
European Union average: 22,3%

Source: Covid-19 vaccine tracker: the global race to vaccinate. *Financial Times*. ECDC. COVID Vaccine Tracker.

[26] Thailand reports highest daily COVID-19 fatalities. Vietnam News Agency. 26 May 2021.

4. Conclusions and Recommendations

"Assuming all vaccine shipments arrive on time, enough doses will be available to meet the government's targets on schedule. However, we do not know whether a 70% vaccination rate will be enough to achieve herd immunity."

Since it is unclear what vaccination rate is needed to reach herd immunity—and it is not even certain that this goal can, in fact, be achieved—the claim that we are 100 days away from herd immunity is based more on logistics than on epidemiology. Assuming all vaccine shipments arrive on time, enough doses will be available to meet the government's targets on schedule. However, the fact remains that we do not know whether 70% will be enough to achieve herd immunity.

Recommendations:

a. **Keep using non-pharmacological preventive measures**. Even if we do reach herd immunity, we must remember that the virus will not disappear all at once. Therefore, we must not relax non-pharmacological measures such as social distancing and wearing masks in enclosed spaces even if vaccination rates reach high levels. Chile provides a cautionary tale: despite a high vaccination rate, the country is facing a complex epidemiological situation and a large surge in cases. The percentage of vaccinated people is not a magic number; it must be considered in context.

b. **Don't leave anyone behind**. Herd immunity targets in a particular country or region are not effective in the long term. As long as some countries do not have widespread access to vaccination, outbreaks will continue to occur and new variants will emerge, putting all countries at risk. We live in an interdependent world, so our health strategy must also be interdependent. This also applies within our country. We need to ensure equitable access to vaccines and remain mindful of barriers that affect particularly vulnerable populations, such as migrants.

c. **Aim for the highest possible vaccination coverage**. Even if we cannot achieve herd immunity, the higher the vaccination coverage, the better we will be able to manage and control the pandemic. Vaccines are not only intended to create herd immunity, but also to protect people—especially the most vulnerable—from the disease and its consequences. This helps to unburden the health system and functionally control the pandemic. An effort should be made to remove any barriers to vaccine access and to build public trust in order to prevent vaccine hesitancy.

d. **Do not disregard the functional control strategy**. For some diseases, such as influenza, we will never achieve herd immunity. It is not yet clear whether SARS-CoV-2 belongs to this group. In any case, it is important to keep vaccinating the population in order to achieve effective control of the pandemic, thereby preventing hospitalisations and deaths. Even if we do not manage to eradicate COVID-19, we can reduce the mortality rate, the infection rate and the social consequences of the disease, which is an achievement in itself.

Herd immunity is an important objective and a priority, but it is not the only solution. Adopting a **global health strategy** to help achieve high vaccination rates worldwide, maintaining some **non-pharmacological measures**, and **strengthening health systems and epidemiological surveillance** are key elements of the joint effort to control this pandemic and prepare for future threats •

TO LEARN MORE

- ISGlobal. FAQs on COVID-19 Vaccines.
- Covid-19 vaccine tracker: the global race to vaccinate. *Financial Times*.
- Christie Aschwanden. Five reasons why COVID herd immunity is probably impossible. *Nature*. 18 March 2021.

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