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When will the COVID-19 pandemic end?

Normalcy by spring, and herd immunity by fall? We assess the prospects for an end in 2021.

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In 1920, a world wearied by the First World War and sickened by the 1918 flu pandemic desperately sought to move past the struggles and tragedies and start to rebuild lives. People were in search of a "return to normalcy," as Warren G. Harding put it. Today, nearly every country finds itself in a similar position.

More than eight months and 900,000 deaths into the COVID-19 pandemic,[1] people around the world are longing for an end. In our view, there are two important definitions of "end," each with a separate timeline:

— *An epidemiological end point when herd immunity is achieved.* One end point will occur when the proportion of society immune to COVID-19 is sufficient to prevent widespread, ongoing transmission. Many countries are hoping that a vaccine will do the bulk of the work needed to achieve herd immunity. When this end point is reached, the public-health-emergency interventions deployed in 2020 will no longer be needed. While regular revaccinations may be needed, perhaps similar to annual flu shots, the threat of widespread transmission will be gone.

— *A transition to a form of normalcy.* A second (and likely, earlier) end point will occur when almost all aspects of social and economic life can resume without fear of ongoing mortality (when a mortality rate is no longer higher than a country's historical average) or long-term health consequences related to COVID-19. The process will be enabled by tools such as vaccination of the highest-risk populations; rapid, accurate testing; improved therapeutics; and continued strengthening of public-health responses. The next normal won't look exactly like the old—it might be different in surprising ways, with unexpected contours, and getting there will be gradual—but the transition will enable many familiar scenes, such as air travel, bustling shops, humming factories, full restaurants, and gyms operating at capacity, to resume.

The two ends are related, of course, but not linearly. At the latest, the transition to normal will come when herd immunity is reached. But in regions with strong public-health responses, normalcy can likely come significantly before the epidemiological end of the pandemic.

The timeline to achieve the ends will vary by location. In this article, we'll explain the criteria that will be key factors in determining when each is reached. In the United States and most other developed economies, the epidemiological end point is most likely to be achieved in the third or fourth quarter of 2021, with the potential to transition to normalcy sooner, possibly in the first or second quarter of 2021. Every day matters. Beyond the impatience that most feel to resume normal life, the longer it takes to remove the constraints on our economies, the greater will be the economic damage.

The epidemiological end point

Most countries have deferred the hope of achieving herd immunity until the arrival of a vaccine. When herd immunity is reached, ongoing public-health interventions for COVID-19 can stop without fear of resurgence. The timing of the end point will vary by country and will be affected by a number of factors:

— the arrival, efficacy, and adoption of COVID-19 vaccines—the biggest drivers in the timeline to herd immunity[2]

— the level of natural immunity in a population from exposure to COVID-19; in our estimate, between 90 million and 300 million people globally may have natural immunity[3]

— potential cross-immunity from exposure to other coronaviruses[4]

— potential partial immunity conferred by other immunizations, such as the bacille Calmette–Guérin (BCG) vaccine for tuberculosis[5]

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[1] Coronavirus Resource Center, Johns Hopkins University & Medicine, September 18, 2020, coronavirus.jhu.edu.
[2] Virus-neutralizing antibodies could also confer immunity but are less likely to be deployed at sufficient scale to achieve herd immunity in large populations.
[3] For calculation and sources, see sidebar, "Key factors affecting the timeline to herd immunity."
[4] Jose Mateus et al., "Selective and cross-reactive SARS-CoV-2 T cell epitopes in unexposed humans," *Science*, August 4, 2020, science. sciencemag.org.
[5] Martha K. Berg et al., "Mandated Bacillus Calmette-Guérin (BCG) vaccination predicts flattened curves for the spread of COVID-19," *Science Advances*, August 2020, Volume 6, Number 32, advances.sciencemag.org.

— regional differences in the ways that people mix, which will produce different thresholds for herd immunity
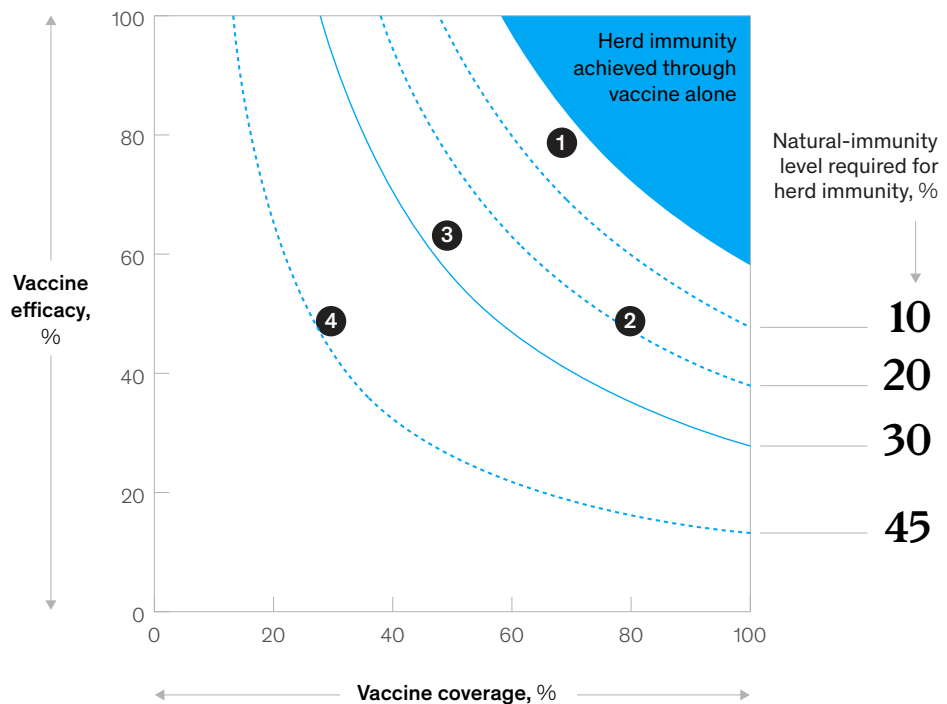
Consider the first and most crucial variables: the arrival of vaccines, their efficacy, and their adoption. We see four plausible scenarios for vaccine efficacy and adoption, illustrated in Exhibit 1.[6] Different combinations of those two

factors will drive varying levels of conferred immunity, implying the extent of natural immunity that will be required to reach herd immunity under each scenario. Combinations of efficacy and adoption beyond those shown are possible.

The other variables will also have much to say about the timeline to reach herd immunity (see sidebar, "Key factors affecting the timeline to herd immunity").

Exhibit 1

Vaccine efficacy and coverage are both important; vaccination alone may not achieve herd immunity.

COVID-19-immunity scenarios[1]

① Optimistic

Efficacy is close to that of common childhood vaccinations; coverage is close to 70% (share of survey respondents willing to receive a vaccine ≤3 months after it is available)

② High coverage

Efficacy meets minimum threshold for approval; coverage is close to that of common childhood immunizations

③ Midpoint

Efficacy is above minimum threshold for approval but less than that of common childhood vaccinations; coverage is similar to that of flu vaccines

④ Pessimistic

Efficacy meets minimum threshold for approval; public hesitance to adopt vaccine similar to healthy adults' adoption of flu vaccines, with relatively low coverage ceilings

[1]COVID-19 herd immunity achieved once total immune population reaches 58%, using basic reproductive number (R0) of 2.4; herd-immunity threshold calculated as 1 − (1/R0).
Source: US Food and Drug Administration; McKinsey COVID-19 Survey, July 17, 2020

[6] Exhibit 1 assumes a basic reproductive number (R0) of 2.4 and uses a standard formula to arrive at an estimated herd-immunity threshold of 58 percent.

Key factors affecting the timeline to herd immunity

Apart from vaccines, several other factors will shape the path to achieving COVID-19 herd immunity in a given population.

Natural immunity to SARS-CoV-2

Globally, of the approximately 30 million people known to have COVID-19, more than 900,000 have died.[1] The rest have recovered and have some degree of natural immunity to SARS-CoV-2 (the novel coronavirus), the virus that causes the disease. While there has been at least a few documented cases of reinfection, most experts expect that the majority of those exposed to the virus are immune for some period of time.

It's likely that many more infections haven't been detected. Estimated case-detection rates range from 3:1 to 10:1.[2] That would mean that between around 90 million and 300 million people around the world have some immunity to SARS-CoV-2.

Infection rates vary widely. In some places, such as Mumbai and New York City, subpopulation antibody-positivity rates range up to 50 percent.[3] But those are likely to be outliers: in most countries, less than 10 percent (and often less than 5 percent) of populations test positive for antibodies.[4]

T-cell cross-reactivity to other coronaviruses

Some recent studies suggest that a significant number of people who haven't contracted COVID-19 have cross-reactivity in specific immune cells (T cells). Most of them gained it from contracting other coronaviruses, which primed their immune systems to react to COVID-19.[5] The degree to which T-cell cross-reactivity actually immunizes individuals hasn't been proven. If T-cell cross-reactivity provides meaningful immunity, it would offer significant progress toward herd immunity. The prevalence of cross-reactive immunity may vary substantially by region.

Partial immunity because of other immunizations

Studies have shown that countries that require bacille Calmette–Guérin (BCG) vaccinations for tuberculosis correlate with lower rates of COVID-19 infections and related deaths, normalizing for certain key factors (such as epidemic stage, development, rurality, population density, and age structure).[6] Causation hasn't been proven.

Threshold for achieving herd immunity

The threshold for achieving herd immunity for COVID-19 is the percentage of a population that needs to develop immunity to disease to prevent sustained future transmission. Once the threshold is reached, the whole population is protected. A basic formula for estimating that threshold is one minus the reciprocal of the basic reproductive number.[7]

In practice, a herd-immunity threshold is complicated and varies by setting. The formula relies on several broad assumptions. One is that each member of a population mixes randomly with all other population members. In reality, people mix mostly with others whose patterns of interaction are similar to their own. Subpopulations with fewer interactions have lower thresholds for herd immunity than do those with more interactions. An estimated overall threshold for herd immunity can be lower than it would be if it took into account that subpopulations with fewer interactions might drive down an overall threshold, and that subpopulations with more interactions have disproportionately already been infected.[8]

Several epidemiologists who are building dynamic models of COVID-19 that incorporate the heterogeneity of population mixing are predicting lower thresholds for herd immunity than previously thought. Many models predict thresholds of about 40 to 50 percent. Other epidemiologists have called into question those hopeful estimates and note that policy should be based on conservative estimates of herd-immunity thresholds until better information is available.[9]

[1] Coronavirus Resource Center, Johns Hopkins University & Medicine, September 18, 2020, coronavirus.jhu.edu.

[2] Charlie Giattino, "How epidemiological models of COVID-19 help us estimate the true number of infections," Our World in Data, August 24, 2020, ourworldindata.org; Hazhir Rahmandad, John Sterman, and Tse Yang Lim, "Estimating COVID-19 under-reporting across 86 nations: Implications for projections and control," medRxiv, August 3, 2020, medrxiv.org.

[3] Not all serosurveys have used random-sampling methodologies.

[4] "COVID-19: Data," NYC Health, September 21, 2020, nyc.gov. Summary statistics, SeroTracker, September 16, 2020, serotracker.com.

[5] Nina Le Bert et al., "SARS-CoV-2-specific T cell immunity in cases of COVID-19 and SARS, and uninfected controls," *Nature*, August 20, 2020, Volume 584, pp. 457–62, nature.com.

[6] Martha K. Berg et al., "Mandated Bacillus Calmette-Guérin (BCG) vaccination predicts flattened curves for the spread of COVID-19," *Science Advances*, August 2020, Volume 6, Number 32, advances.sciencemag.org.

[7] The basic reproductive number (R0) is a measure of contagiousness or transmissibility. For COVID-19, it can be generally thought of as the expected number of cases directly generated by a single case in a population in which all people are susceptible. The R0 value for COVID-19 is under debate, with estimates ranging from two to four. For an example of a low-end estimate, see Max Fisher, "R0, the messy metric that may soon shape our lives, explained," *New York Times*, April 23, 2020, nytimes.com. For an example of a high-end estimate, see Seth Flaxman et al., "Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe," *Nature*, August 13, 2020, Volume 584, pp. 257–61, nature.com.

[8] Frank Ball, Tom Britton, and Pieter Trapman, "A mathematical model reveals the influence of population heterogeneity on herd immunity to SARS-CoV-2," *Science*, August 14, 2020, Volume 369, Number 6,505, pp. 846–9, science.sciencemag.org.

[9] *Abstractions Blog*, "The tricky math of herd immunity for COVID-19," blog entry by Kevin Hartnett, June 30, 2020, quantamagazine.org; Apoorva Mandavilli, "What if 'herd immunity' is closer than scientists thought?," *New York Times*, August 17, 2020, nytimes.com.

Based on our reading of the current state of the variables and their likely progress in the coming months, we estimate that the most likely time for the United States to achieve herd immunity is the third or fourth quarter of 2021. As we wrote in July 2020, one or more vaccines may receive US Food and Drug Administration Emergency Use Authorization before the end of 2020 (or early in 2021) and the granting of a Biologics License Application (also known as approval) during the first quarter of 2021.
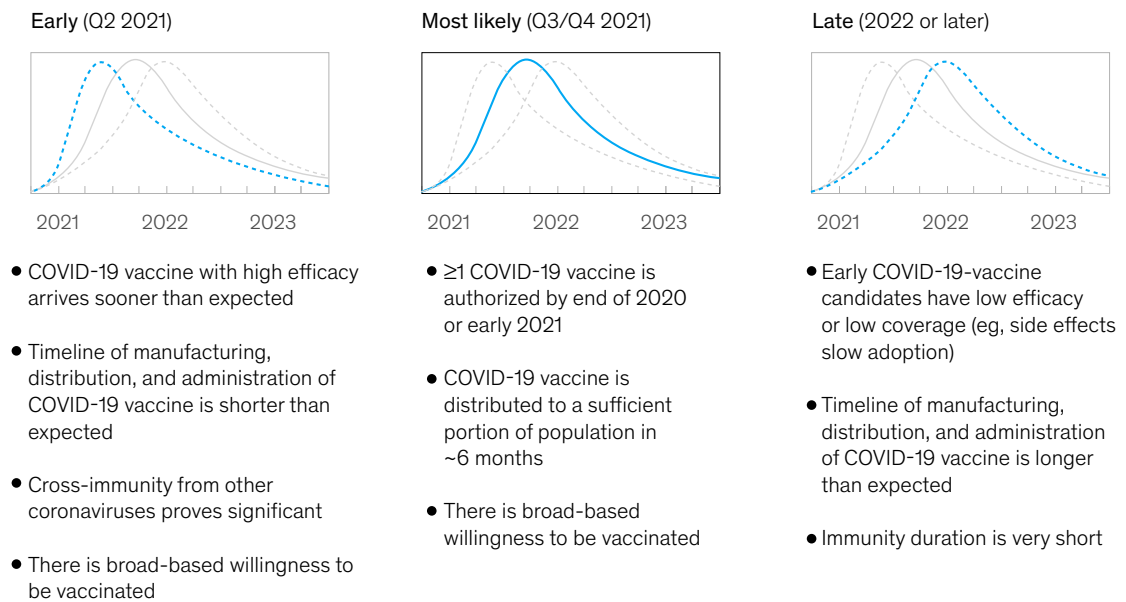
Vaccine distribution to a sufficient portion of a population to induce herd immunity could take place in as few as six months. That will call for rapid availability of hundreds of millions of doses, functioning vaccine supply chains, and peoples' willingness to be vaccinated during the first half of 2021. We believe that those are all reasonable expectations, based on public statements from vaccine manufacturers and the results of surveys on consumer sentiment about vaccines.[7]

Herd immunity could be reached as soon as the second quarter of 2021 if vaccines are highly effective and launched smoothly or if significant cross-immunity is discovered in a population (Exhibit 2). (For more on the potential for a faster resolution of the COVID-19 crisis in the United States, see "Searching for optimism in the US response to COVID-19," forthcoming on McKinsey.com.) On the other hand, the epidemiological end of the pandemic might not be reached until 2022 or later if the early vaccine candidates have efficacy or safety issues— or if their distribution and adoption are slow. At worst, we see a long-tail possibility that the United States could be still battling COVID-19 into 2023 and beyond if a constellation of factors (such as low efficacy of vaccines and a short duration of natural immunity) align against us.

Exhibit 2

The probability of reaching COVID-19 herd immunity in the United States is highest in the third or fourth quarter of 2021 but could shift.

Probability of functional end[1] to COVID-19 pandemic in US by quarter (illustrative)

Early (Q2 2021)

2021   2022   2023

- COVID-19 vaccine with high efficacy arrives sooner than expected

- Timeline of manufacturing, distribution, and administration of COVID-19 vaccine is shorter than expected

- Cross-immunity from other coronaviruses proves significant

- There is broad-based willingness to be vaccinated

Most likely (Q3/Q4 2021)

2021   2022   2023

- ≥1 COVID-19 vaccine is authorized by end of 2020 or early 2021

- COVID-19 vaccine is distributed to a sufficient portion of population in ~6 months

- There is broad-based willingness to be vaccinated

Late (2022 or later)

2021   2022   2023

- Early COVID-19-vaccine candidates have low efficacy or low coverage (eg, side effects slow adoption)

- Timeline of manufacturing, distribution, and administration of COVID-19 vaccine is longer than expected

- Immunity duration is very short

[1]Timeline to functional end is likely to vary somewhat based on geography.
Source: Expert interviews; press search; McKinsey analysis

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[7] Joe Myers, "3 in 4 adults around the world say they would get a COVID-19 vaccine," World Economic Forum, September 1, 2020, weforum.org.

The paths to herd immunity in other high-income countries are likely to be broadly similar to the one in the United States. The timelines will vary based on differences in vaccine access and rollout and in levels of natural immunity—and potentially, in levels of cross-immunity and previous coverage of other vaccines, such as the BCG vaccine. Even as some locations reach herd immunity, pockets of endemic COVID-19 disease are likely to remain around the world, for example in areas affected by war or in communities with persistently low adoption of vaccines. In such places, until herd immunity is reached, COVID-19 might be analogous to measles— not a day-to-day threat to most people, but a persistent risk. If immunity wanes—for example, if booster vaccines are not fully adopted—then COVID-19 could become more widely endemic.

The arrival of herd immunity won't mean a complete end to all public-health interventions. It's possible that regular revaccinations would be required to maintain immunity, and ongoing surveillance for COVID-19 will be required. But herd immunity would mean that the emergency measures currently in place in many countries could be lifted.

The pace at which governments relax public-health measures will be critical. Some of those measures (such as full lockdowns and restrictions on certain industries) have significant social and economic consequences, and others (such as testing and tracing), while expensive, don't. Many governments are employing packages of measures that aim to minimize the number of COVID-19 cases and excess mortality while maximizing social and economic degrees of freedom.
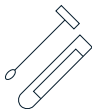
The transition to normal

The second end point of the pandemic may be reached earlier than the first. We estimate that the mostly likely time for this to occur is the first or second quarter of 2021 in the United States and other advanced economies. The key factor is diminished mortality.

Society has grown used to tracking the number of COVID-19 infections (the case count). But case counts matter primarily because people are dying from the disease and because those who survive it may suffer long-term health consequences after infection. The latter is an area of scientific uncertainty, but there is concern that some recovered patients will face long-term effects.[8]

Exhibit 3

Reduced COVID-19-related mortality might be achieved through many factors simultaneously.

Factors that could reduce COVID-19 related mortality

Immunity through COVID-19 vaccine
Rolling out an effective COVID-19 vaccine in high-risk populations could significantly reduce related mortality

Cross-immunity
Potential T-cell cross-reactivity immunity of SARS-CoV-2 and other coronaviruses being researched

Immunity through other vaccines
Potential correlation between BCG[1] vaccination and lower COVID-19 case counts and related mortality being researched

Decreased rate of transmission
Faster identification of COVID-19 and isolation measures through rapid, accurate testing could reduce related mortality and allow quicker resumption of activities (eg, air travel)

Better treatment
Improved understanding of COVID-19 and advances in its treatment could significantly decrease related mortality

Natural immunity
A larger population with COVID-19 immunity through exposure could reduce related mortality

[1]Bacille Calmette–Guérin (BCG) vaccine is widely used as a prevention strategy against tuberculosis.

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[8] "COVID-19 (coronavirus): Long-term effects," Mayo Clinic, August 18, 2020, mayoclinic.org.

Most countries have made significant progress in reducing the numbers of deaths and hospitalizations associated with COVID-19. Some are close to eliminating excess mortality. Those results have generally been achieved through a combination of moderately effective interventions rather than a single "big bang" (Exhibit 3).

A transition to the next normal, in whatever form that takes, will come gradually when people have confidence that they can do what they used to do without endangering themselves or others. Gaining that confidence will require a continuation of the progress made to reduce mortality and complications, as well as further scientific study regarding long-term health consequences for recovered patients. When confidence is restored, people will again fill bars, restaurants, theaters, and sports venues to full capacity; fly overseas (except for the highest-risk populations); and receive routine medical care at levels similar to those seen prior to the pandemic.

The timing of such a transition will depend on the progress toward herd immunity, as previously detailed (since more people with immunity means fewer deaths and long-term health consequences), and on the effectiveness of a country's public-health response. Transitions will be gradual. They have already begun in some locations and could be well advanced in most countries by the first or second quarter of 2021. Given the interconnectedness of the global economy, country timelines to normalcy are not fully independent of one another.

To achieve that, we will need to see significant progress on the epidemiological end point, including an effective vaccine receiving Emergency Use Authorization approval during the fourth quarter of 2020 or the first quarter of 2021, followed by a smooth rollout and adoption by high-risk populations. Favorable findings on natural and cross-immunity would help accelerate timelines. Five additional criteria will also contribute to the transition to a form of normalcy—the more of these that are achieved, the faster the milestone is likely to be reached:

— continued improvement by governments in the application of public-health interventions (such as test and trace) that don't significantly limit economic and social activities

— compliance with public-health measures until we achieve herd immunity

— accurate, widely available, rapid testing that effectively enables specific activities

— continued advancements in therapeutics (including pre- and postexposure prophylactics) for and clinical management of COVID-19, leading to lower infection-fatality ratios—substantial progress has already been made through a combination of effective drugs, such as dexamethasone and remdesivir, and changes in clinical management

— public confidence that there aren't significant long-term health consequences for those who recover from COVID-19

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Both the epidemiological and normalcy ends to the COVID-19 pandemic are important. The transition to the next normal will mark an important social and economic milestone, and herd immunity will be a more definitive end to the pandemic. In the United States, while the transition to normal might be accomplished sooner, the epidemiological end point looks most likely to be reached in the second half of 2021. Other advanced economies are probably on similar timetables.