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All in the mix: Why US COVID-19 cases rose and fell, and what comes next

Some people get out and about more than others. That might be a key and overlooked factor in recent declines in US COVID-19 case counts—and could have implications as society reopens.

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New US COVID-19 cases rose sharply in late 2020 and declined nearly as steeply during the first few months of 2021 until recently. This is similar to the pattern of other respiratory viruses in the winter months, but in this case many are not sure precisely why it has happened. In this article, we examine one potential, underexplored factor: the different patterns of human interaction. Some people come in close contact with a lot of other people, while others have fewer connections. Epidemiologists call this "heterogeneous mixing," though most models of the spread of COVID-19 don't account for it; they assume everyone interacts in similar ways. It's also not well understood by the general public.

We factored the more disparate ways people mix into our standard epidemiological model for COVID-19 and found that the model's forecasts of case counts, adjusted for uneven mixing patterns, better reflect actual case counts. As with every aspect of COVID-19, it's too soon to assert causation; there's still too much about the disease we don't understand. But we think this connection is worth examining, as are its implications for the speed at which society reopens. A critical concern is the group of people who have not seen many other people in the past year but may now reengage with society, even if they are not vaccinated. Public-health leaders may wish to think through their messages for this group.

Human beings are social beings

In the course of a day, some people interact with many others. Retail workers, teachers, delivery drivers, and many others meet with lots of people every day, as part of their jobs. And others (spring-breakers, for example) may feel that the threat of the disease to them is low, so they continue to maintain their daily interactions. We would consider people in both of these groups "high mixers." In contrast, low mixers would include people who can work from home or who tend to be risk averse.

Traditional epidemiological models typically assume populations mix in about the same ways, at least within age groups; they don't account for different types of mixing by different age groups. Research on this topic is somewhat limited, with data on mixing difficult to find and concrete conclusions not readily apparent.[1] Exhibit 1 outlines the potential for different conclusions, depending on whether an epidemiological model assumes even or uneven mixing. In both, the average number of contacts per person is two. But in a model that considers high and low mixers, the average comes from a small number of people with a lot of contacts (about four times that of the larger group that sees fewer people, according to research from the University of California, Berkeley),[2] and a large number of people who see only a single other person. Introduce COVID-19 into the population, and you'd expect more transmission in high mixers than in lower mixers.

It's a critical difference, as we explore next.

Rapid spread, rapid decline

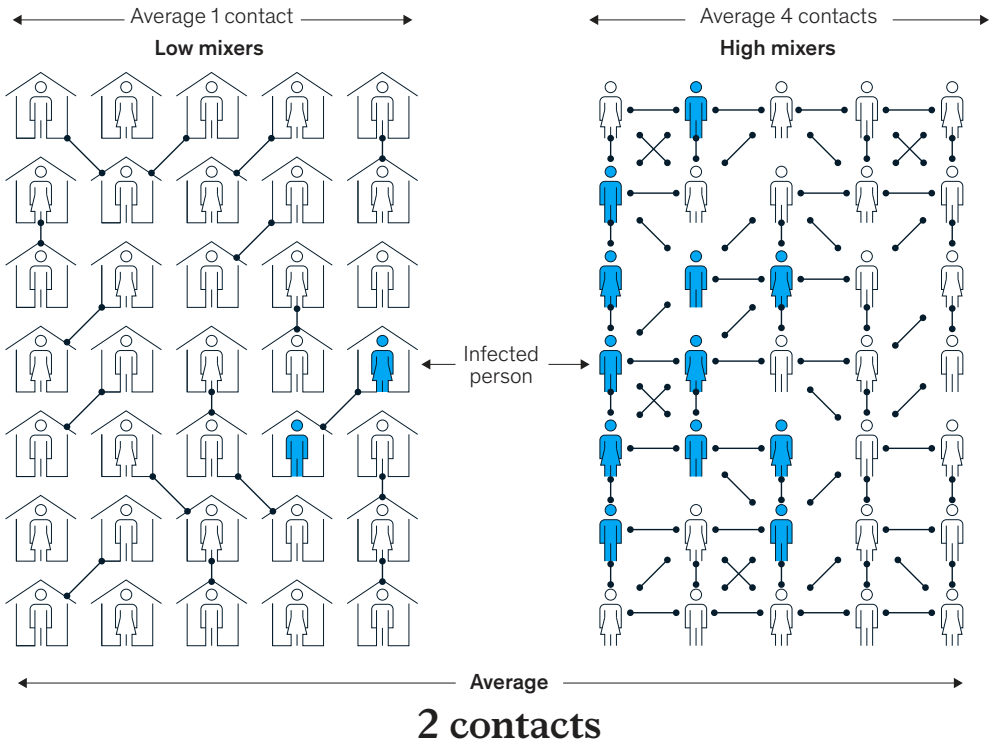
To further understand the phenomenon, we need to know the proportions of the two groups, high and low mixers. Mobile-phone data suggests that most of us are homebound or remaining close to home, though some people remain quite active.[3] Data on air travel suggests something similar: passenger levels in 2020 were about 70 percent below 2019 levels.[4] Researchers at the University of California, Berkeley, surveyed Americans about their contacts at different times during the pandemic and gauged the extent to which interpersonal contact has declined.[5] They found that, on average, we have about 82 percent less close contact than we did prior to the pandemic.

[1] 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 2020, Volume 369, Issue 6505, pp. 846–9, sciencemag.org; Ricardo Aguas et al., "Herd immunity thresholds for SARS-CoV-2 estimated from unfolding epidemics," *MedRxiv*, November 16, 2020, medrxiv.org.
[2] Dennis M. Feehan and Ayesha S. Mahmud, "Quantifying population contact patterns in the United States during the COVID-19 pandemic," *Nature Communications*, February 2021, Volume 12, nature.com.
[3] "Daily travel during the COVID-19 public health emergency," Bureau of Transportation Statistics, September 2, 2020, bts.gov.
[4] TSA checkpoint travel numbers (current year[s] versus prior year/same weekday), Transportation Security Administration, March 15, 2021, tsa.gov.
[5] Feehan, *Nature Communications*, 2021.

Exhibit 1

The dynamics of uneven mixing can expand COVID-19 transmission.

Number of interactions and COVID-19 infections within 2 weeks with uneven mixing in a population (illustrative)



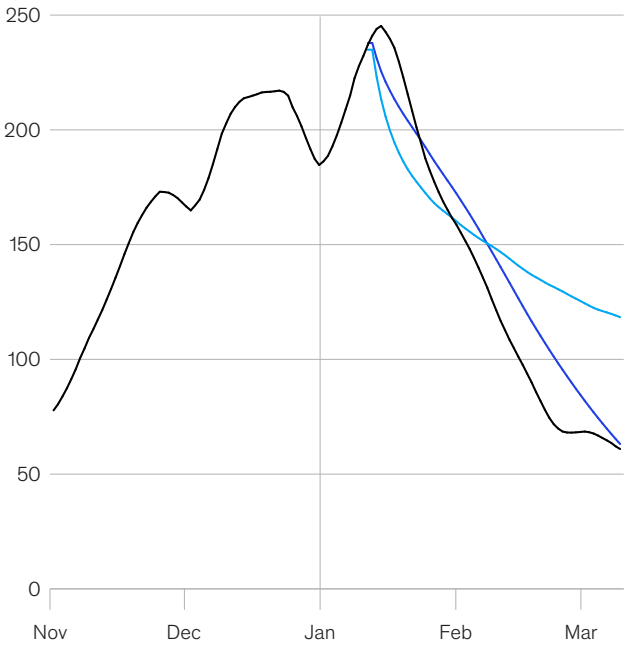
Source: McKinsey analysis

Using these sources, we estimate that in late 2020, about 70 percent of the population are low mixers, while 30 percent are highly active (and include people attending so-called super-spreading events). We used these estimates, along with estimates of the number of contacts each group has on average (two and eight) based upon the UC Berkeley research, in the McKinsey Global COVID-19 epidemiology model, to estimate the progression and decline in cases for the period starting January 11, 2021 (near the peak of actual cases) and ending March 9, 2021 (Exhibit 2). The uneven-mixing scenario closely fits the sustained decline seen in the line representing actual cases, and corresponds much more closely than does a projection using the traditional epidemiological assumption of even mixing within age groups in the population. We also confirmed that the increase in cases at the end of 2020 is plausible under the uneven-mixing scenario.

Exhibit 2

A projection based on uneven mixing best approximates the drop in COVID-19 cases.

US daily detected cases under various mixing scenarios,[1] thousands



Even mixing: assumes nonheterogeneous mixing within an age group, though does allow for different amounts of mixing across and between age groups

Uneven mixing: assumes 30% of the population has 4x as many contacts as the remaining 70% and allows for different amounts of mixing across and between age groups

Actual case count: (7-day rolling average)

[1]Nov 1, 2020–Mar 9, 2021.
Source: Our World in Data; McKinsey Global COVID-19 Epidemiology model

It seems plausible that high mixers, with their much wider networks of interaction, could be responsible for a substantial portion of the steep rise in cases in late 2020; in particular, gatherings of friends and family over Thanksgiving, December holidays, and New Year's Day may have hastened transmission, even if much of it was asymptomatic. (Some low mixers likely also participated in the holiday festivities, and then retreated to their previous behaviors.[6]) Subsequently, these high mixers may have recovered quickly—the UC Berkeley research finds that many are young men—and as their disease has receded, they have stopped spreading it. Put another way, the people in the population most likely to get sick and spread the disease may have done just that—and with that burst of transmission out of the way, overall case counts have fallen.

Super-spreading events have captured the popular imagination and are certainly a factor in the rise and fall of case counts. But in our estimate, the group of high mixers, many of whom might have attended these events, may be even more important to consider.

[6] David Lazer et al., "The COVID State Project #34: Update on holiday gatherings in December 2020," January 25, 2021, covidstates.org.

It takes all kinds to make a herd

One endpoint of the pandemic will come when a society reaches what we call herd immunity—when enough of the population has immunity from the virus that spread is minimal. Vaccination is, of course, a critical variable in the calculation, but so too is natural immunity. High mixers and low mixers will likely make different contributions to that outcome, as they likely have different levels of natural immunity to COVID-19 after recovering from infection. We estimate that, as of mid-January 2021, 45 to 55 percent of high mixers could have natural immunity, versus about 15 to 25 percent of low mixers. Recent McKinsey consumer research indicates that high mixers are also less likely to get vaccinated against COVID-19 or follow public-health guidelines (for example, those unlikely to get vaccinated are 3.5 times more likely to not wear a face mask properly in indoor public places and almost twice as likely to go to bars and attend indoor events than individuals likely to get vaccinated).[7] Natural immunity may be the high mixers' path to protection, for better or worse. Our analysis suggests that, based on the past few months of case trends, high mixers could have relatively high levels of immunity by summer of 2021; this group already has a substantially lower proportion of people susceptible to the original COVID-19 strain than low mixers.

That's an important factor in the quest for herd immunity. As long as high mixers and low mixers do not change their behaviors significantly and the rise of variants does not meaningfully increase the number of susceptible high mixers, the threshold for herd immunity is lower than it would be if people mixed evenly. Social butterflies are unlikely to become introverts, and people whose jobs call for them to meet the public will continue to have lots of contacts. The behavior to watch for is when countries reopen and unvaccinated low mixers start to reengage with others. We expect more of that in the second quarter of 2021, as regions and countries start to reopen and contend with the rise of variants.[8] What happens then? It's one of the three implications that leaders should consider and that we'll continue to study.

Three implications of uneven mixing

Our analysis highlights three implications for leaders as they consider the timing of reopening and continue to ensure that populations are safe.

1. *Pay attention to the low mixers.* What they do next matters a lot. As the decline in cases has tapered in recent weeks (and even reversed, with new case growth in some geographies), one can assume mixing patterns have not stayed constant—it's likely that more people are beginning to mix, especially as areas begin reopening. There is likely a gradient of risk-taking behavior in the low-mixer group, though we can consider three potential types of people: those who will maintain their behaviors until they are vaccinated or public-health guidelines change, those who are already vaccinated and beginning to mix again, and those who will resume daily activities without being vaccinated or without public-health guidelines changing. As societies reopen, the first group may have fewer contacts than they did before the pandemic, and the second group may have more, due to pent-up demand.[9] The second group may be less of a worry because they are vaccinated; they are less susceptible to severe illness, and also less likely to contribute to transmission. However, as less risk-averse individuals in the third group see others mixing and increasing interactions or reach their limits of pandemic fatigue, they may begin to gradually take steps toward mixing, even without being vaccinated. The number of people who will resume daily activities without natural or vaccine-mediated immunity has immense implications for safely reopening, especially as variants take hold. This group could drive reopening dynamics and should be top of mind for public- and private-sector leaders.

[7] "COVID-19 Consumer Healthcare Insights: What 2021 may hold," January 22, 2021, February 19, 2021, McKinsey.com.
[8] Sarun Charumilind, Matt Craven, Jessica Lamb, Adam Sabow, and Matt Wilson, "When will the COVID-19 pandemic end?" January 20, 2021, McKinsey.com.
[9] *The consumer demand recovery and lasting effects of COVID-19*, McKinsey Global Institute, March 17, 2021, McKinsey.com.

2. *The true effect of variants is still unknown.* New variants that are potentially more infectious and to which high mixers could have low cross-immunity[10] may lead to a renewed rise in cases similar to what we saw after the 2020 holidays. If mixing remains the same as we suspect it has been recently, the effect of variants on case counts may be shorter than the original COVID-19 strain, as variants could spread faster in the group of people mixing. Another factor that may limit the spread of variants is the natural seasonality of respiratory viruses.

   On the other hand, If unvaccinated low mixers start mixing more (due to, for example, nicer weather, resumption of travel, or loosening of local public-health guidelines) they could fuel a variant's rise before the vaccine race is won. We are already seeing potential evidence of more mixing, and this could fuel another wave of cases.

3. *The race to vaccinate is on.* Vaccines have generally proved effective, and may be the best tool we have to reduce potential adverse outcomes of increasing the amount of mixing in the population. This will require relatively high vaccine coverage rates and continued public messaging regarding the importance of vaccines to end the COVID-19 pandemic.

The world has rightly focused on the big puzzle pieces of the pandemic, such as vaccines and variants. Uneven mixing is another such piece that leaders should consider as they plan for a postpandemic world.

[10] Such as P.1 or B.1.351.

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