

COVID-19 'super-spreading' events play outsized role in overall disease transmission

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There have been many documented cases of COVID-19 "super-

spreading" events, in which one person infected with the SARS-CoV-2 virus infects many other people. But how much of a role do these events play in the overall spread of the disease? A new study from MIT suggests that they have a much larger impact than expected.

The study of about 60 super-spreading events shows that events where one person infects more than six other people are much more common than would be expected if the range of transmission rates followed statistical distributions commonly used in epidemiology.

Based on their findings, the researchers also developed a mathematical model of COVID-19 transmission, which they used to show that limiting gatherings to 10 or fewer people could significantly reduce the number of super-spreading events and lower the overall number of infections.

"Super-spreading events are likely more important than most of us had initially realized. Even though they are extreme events, they are probable and thus are likely occurring at a higher frequency than we thought. If we can control the super-spreading events, we have a much greater chance of getting this pandemic under control," says James Collins, the Termeer Professor of Medical Engineering and Science in MIT's Institute for Medical Engineering and Science (IMES) and Department of Biological Engineering and the senior author of the new study.

MIT postdoc Felix Wong is the lead author of the paper, which appears this week in the *Proceedings of the National Academy of Sciences*.

Extreme events

For the SARS-CoV-2 virus, the "basic reproduction number" is around 3, meaning that on average, each person infected with the virus will spread it to about three other people. However, this number varies widely from person to person. Some individuals don't spread the disease

to anyone else, while "super-spreaders" can infect dozens of people. Wong and Collins set out to analyze the statistics of these super-spreading events.

"We figured that an analysis that's rooted in looking at super-spreading events and how they happened in the past can inform how we should propose strategies of dealing with, and better controlling, the outbreak," Wong says.

The researchers defined super-spreaders as individuals who passed the virus to more than six other people. Using this definition, they identified 45 super-spreading events from the current SARS-CoV-2 pandemic and 15 additional events from the 2003 SARS-CoV outbreak, all documented in scientific journal articles. During most of these events, between 10 and 55 people were infected, but two of them, both from the 2003 outbreak, involved more than 100 people.

Given commonly used statistical distributions in which the typical patient infects three others, events in which the disease spreads to dozens of people would be considered very unlikely. For instance, a normal distribution would resemble a bell jar with a peak around three, with a rapidly-tapering tail in both directions. In this scenario, the probability of an extreme event declines exponentially as the number of infections moves farther from the average of three.

However, the MIT team found that this was not the case for [coronavirus](#) super-spreading events. To perform their analysis, the researchers used mathematical tools from the field of extreme value theory, which is used to quantify the risk of so-called "fat-tail" events. Extreme value theory is used to model situations in which extreme events form a large tail instead of a tapering tail. This theory is often applied in fields such as finance and insurance to model the risk of extreme events, and it is also used to model the frequency of catastrophic weather events such as

tornadoes.

Using these mathematical tools, the researchers found that the distribution of coronavirus transmissions has a large tail, implying that even though super-spreading events are extreme, they are still likely to occur.

"This means that the probability of extreme events decays more slowly than one would have expected," Wong says. "These really large super-spreading events, with between 10 and 100 people infected, are much more common than we had anticipated."

Stopping the spread

Many factors may contribute to making someone a super-spreader, including their viral load and other biological factors. The researchers did not address those in this study, but they did model the role of connectivity, defined as the number of people that an infected person comes into contact with.

To study the effects of connectivity, the researchers created and compared two mathematical network models of disease transmission. In each model, the average number of contacts per person was 10. However, they designed one model to have an exponentially declining distribution of contacts, while the other model had a fat tail in which some people had many contacts. In that [model](#), many more people became infected through super-spreader events. Transmission stopped, however, when people with more than 10 contacts were taken out of the network and assumed to be unable to catch the virus.

The findings suggest that preventing super-spreading events could have a significant impact on the overall transmission of COVID-19, the researchers say.

"It gives us a handle as to how we could control the ongoing pandemic, which is by identifying strategies that target super-spreaders," Wong says. "One way to do that would be to, for instance, prevent anyone from interacting with over 10 people at a large gathering."

The researchers now hope to study how biological factors might also contribute to super-spreading.

More information: Felix Wong et al, Evidence that coronavirus superspreading is fat-tailed, *Proceedings of the National Academy of Sciences* (2020). [DOI: 10.1073/pnas.2018490117](https://doi.org/10.1073/pnas.2018490117)

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