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How well do masks protect against COVID-19?

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Abstract

COVID-19 has changed our lives. Since the beginning of the pandemic, many countries have introduced various restrictions. Most of us had to stay at home, distance ourselves from others, and wear face masks in public spaces for some period of time. Two years in, COVID-19 is still affecting us. Many people still have to keep their physical distance and wear masks. So are these measures effective? We tested what would happen if a sick person and a healthy one got together and talked for some time. We found out that social distancing alone isn't effective. There is a 90% chance that a healthy person 3m (10ft) away will get infected in less than 5 minutes. However, if both wear a protective mask, this risk goes down considerably – even if they are standing quite close together!

Introduction

It's been two years since the beginning of the **COVID-19** pandemic. Even now many of us have to wear **face masks** and distance ourselves from others. But why is that?

SARS-CoV-2, the virus that causes COVID-19, spreads through small **droplets**. We produce them during coughing, sneezing, speaking, and even when we breathe. And if we carry the virus (even when we don't realize it), there will be **virions** in these droplets. Thus, we can infect others.

The droplets can be big in size (above 50 **microns**), and then they fall quickly to the ground. In this case, we have to be pretty close to another person to infect them. But droplets can also be smaller, meaning that they can stay and travel in the air for quite some time. And when they travel so far, they may shrink as evaporation takes away some of the moisture.

It's alarming that SARS-CoV-2 can spread with such ease! This is why wearing face masks in public places is **mandatory** in many countries. Governments also often encourage or require **social distancing**. But do these measures stop SARS-CoV-2 from spreading? How much do masks and social distancing reduce the risk of infection with the virus? This is what we wanted to find out.

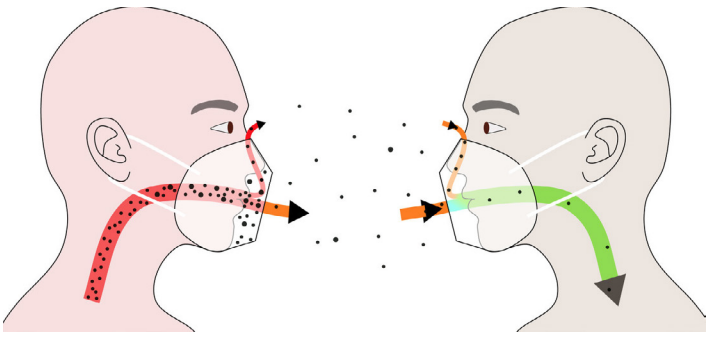

Figure 1:
Masks protect both the wearer and the people nearby. Still, some droplets leak out (and in) of the mask, both through the filter itself (big arrows) and around the edges of the mask (little arrows).

Source: Birte Thiede / MPIDS

Methods

We invited 130 healthy volunteers from age 5 to 80 to help us figure out what we release into the air. We measured the droplets they produced while breathing out and talking both with and without masks. We also compared two different types of masks: FFP2 masks (similar to N95 masks) and surgical masks.

Now, imagine two people are facing each other and talking. One of them is infectious: they carry the SARS-CoV-2 virus. The other one is **susceptible**: they have no **immunity** (against COVID-19) and can become sick. We considered three scenarios:

1. Neither one is wearing a mask but they keep a distance;
2. Only the susceptible person is wearing a mask and they still keep a distance;
3. Both are wearing masks and standing right next to each other.

The risk of infection in the first scenario depends mainly on the **viral load**, **infectious dose**, and how much people's breath dilutes in the surrounding air. We assumed the most common values for these parameters that many researchers report.

For the other two scenarios, we also had to estimate what percentage of the droplets might leak in and out of the masks (Figure 1). There are two main ways for this leakage to happen: the droplets either penetrate the filter itself or slip around the edges. To estimate the leakage, we used a **particle size spectrometer**. It allowed us to count particles in the air and inside the mask. Comparing both counts gives us an accurate idea of what goes in (and out of) the mask.

Results

The bad news is that social distancing alone doesn't protect against infection. Even at a distance of 3m (10 ft), there is a 90% chance the susceptible will become infected in less than 5 minutes!

However, if only the susceptible wear a surgical mask, it will take at least 30 minutes to become infected even at a distance of 1.5m (5 ft) from the infectious. And if the susceptible wear an FFP2 mask, the chances of infection even after an hour are only about 20%.

Of course, the best scenario is when both the infectious and the susceptible wear a mask. If both wear surgical masks, the risk of infection after one hour is below 30%. And if both masks are FFP2, the risk stays below 0.4%! Figure 2 shows more detailed results for various mask combinations.

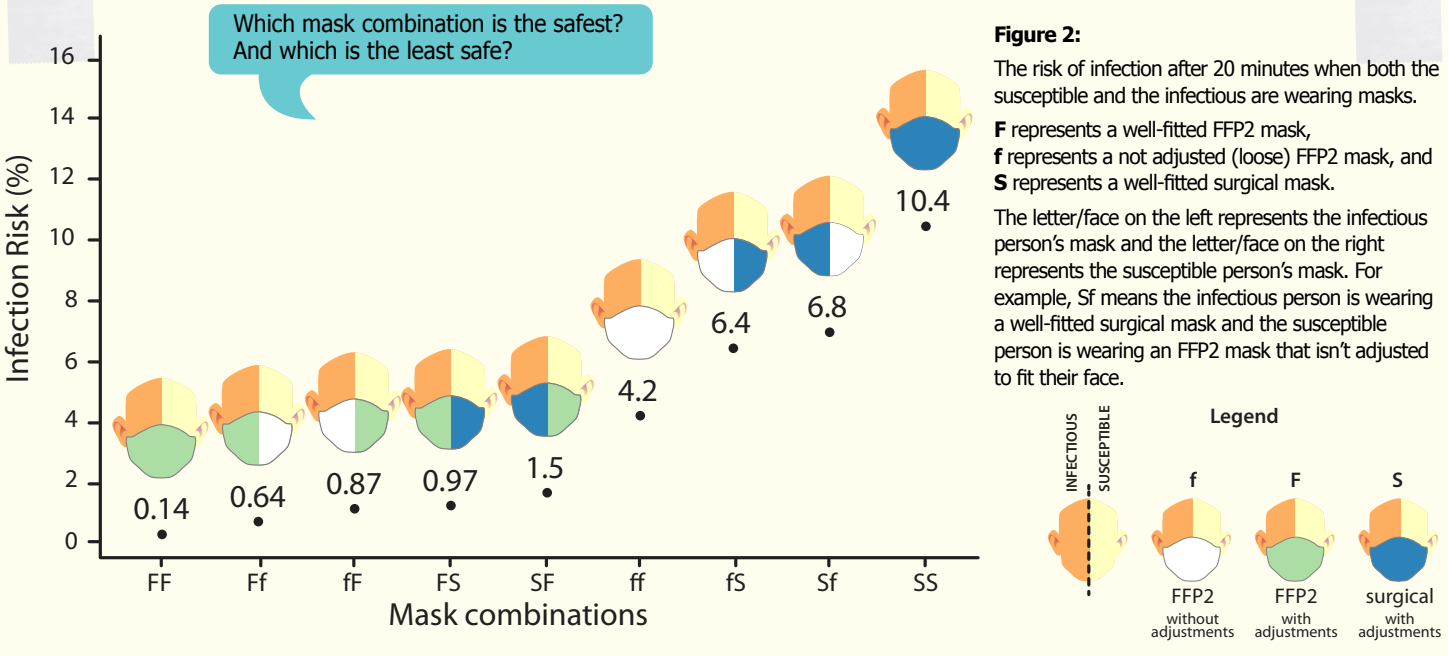

Figure 2:

The risk of infection after 20 minutes when both the susceptible and the infectious are wearing masks.

F represents a well-fitted FFP2 mask,
f represents a not adjusted (loose) FFP2 mask, and
S represents a well-fitted surgical mask.

The letter/face on the left represents the infectious person's mask and the letter/face on the right represents the susceptible person's mask. For example, Sf means the infectious person is wearing a well-fitted surgical mask and the susceptible person is wearing an FFP2 mask that isn't adjusted to fit their face.

Discussion

If people depend only on physical distancing, the risk of infection is very high even after just a few minutes. This doesn't mean we should stop doing it, though. Droplets containing virions are unlikely to reach us when we are 3m (10ft) away. The closer we get, the more likely we are to be infected even in a short period.

But masks are definitely the more effective measure. If the susceptible wear a mask, it reduces the risk a bit but not much. If you talk to your infected friend for an hour while wearing an FFP2 mask, there is a 1 in 5 chance you'll get infected. And if you wear a surgical mask, you'll get infected after only half an hour. Everyone wearing a mask is the best way to protect ourselves and others.

It's important that you fit the mask to your face by adjusting the nosepiece so the mask edge is against your skin (Figure 3). That's how you reduce the leakage of droplets. If you don't adjust your FFP2 mask, the risk is much higher! It increases 10-fold compared to a well-fitted mask! And even a loose FFP2 mask protects better than a well-fitted surgical mask.

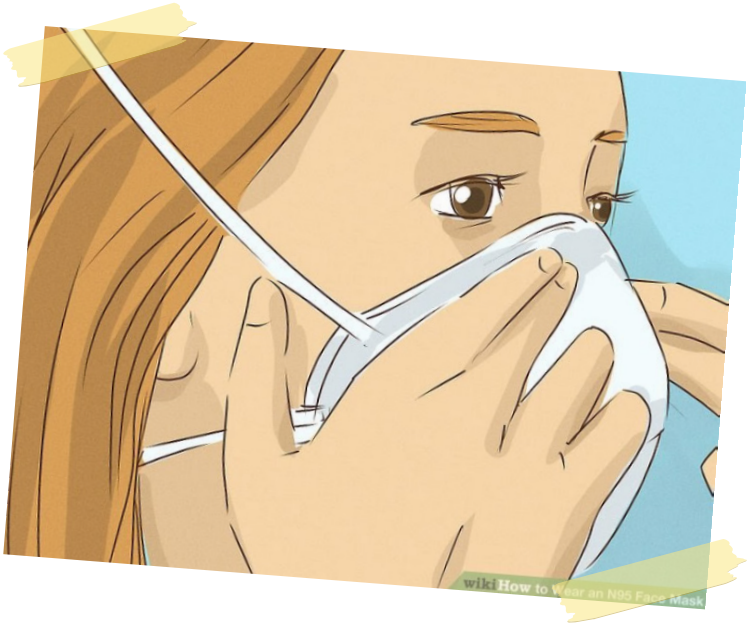

Figure 3:
Adjust your mask for a good fit. Push in on either side of your nose so that the mask edge touches your skin. This reduces the amount of droplet leakage.
Source: wikiHow, CC BY-NC-SA 3.0

Conclusion

Our results show the high end of risk based on the experiment parameters. In real-life situations, they can be lower, due to various factors. Still, wearing either an FFP2 or a surgical mask is a very effective measure to stop the virus from spreading.

Wearing a mask outside and at school can be annoying. But doing so means you protect not only yourself but also your family and friends. When you do wear a mask, don't forget to fit it well to your face. Remember not to touch your eyes and mouth, either. And of course, wash your hands often!

REFERENCES

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Max Planck Society: How to Fit a Mask
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CDC: Your Guide to Masks
https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/about-face-coverings.html

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https://kids.nationalgeographic.com/science/article/facts-about-coronavirus

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Glossary of Key Terms

COVID-19 – Coronavirus disease 2019, a disease caused by SARS-CoV-2. Symptoms may include fever and dry cough in milder cases and difficulty breathing in more severe cases, but there are many who are infected and have no symptoms.

Droplet – when we breathe, talk, sneeze, cough, etc., we send tiny droplets into the air. So they come from our respiratory tract. If we are sick with a respiratory disease (i.e. COVID-19), we can infect others with these droplets.

Face mask – one type of personal protective equipment (PPE). Face masks (and their filters) block the droplets we produce during speaking, breathing, etc. They protect the wearer, too, by filtering the inhaled air. Thus, masks reduce how easily viruses (and other pathogens) spread from one person to another. We tested two types of masks: surgical (medical) face masks and FFP2 masks. Surgical masks filter between 42 and 88% of the virions. FFP2 masks filter between 83 and 99%.

Immunity – the ability of your body's defense system (immune system) to fight off disease. We gain immunity either by being exposed to the disease (natural immunity) or by vaccination (acquired immunity).

Infectious dose – the amount of pathogen (viruses, bacteria, etc.) that is enough to infect another person. Sometimes even 10 virions are enough to infect another person. We assumed an infectious dose of 200 virions, while others used values of 100 to 1000 virions.

Mandatory – required, something that you have to do.

Micron – micrometer, one millionth of the meter. A human hair is around 75 microns across. The SARS-CoV-2 is around 0.1 microns.

Particle size spectrometer – a scientific instrument that can measure the size and concentration of particles in the air.

SARS-CoV-2 – Severe acute respiratory syndrome coronavirus 2, the coronavirus (a group of closely related viruses that usually cause respiratory infections) that causes COVID-19 in humans.

Social distancing – deliberately increasing the space between people to avoid spreading illness.

Susceptible – when someone is more likely to get infected because they are not immune (they hadn't been infected before, and they are not protected by a vaccine).

Virion – a complete, infectious viral particle.

Viral load – the number of virions in a certain volume (e.g. saliva).

Check your understanding

1. How does SARS-CoV-2 most commonly spread? Can you think of any other ways?
2. What is the idea behind social distancing? What did we find out about it?
3. What is the problem with a mask that does not fit tightly?
4. Masks can also prevent other diseases like the flu from spreading. Why do you think many countries made them mandatory during the COVID-19 pandemic but not every flu season?
5. What are the current anti-COVID-19 restrictions in your country? Do you think they are good enough? Would you change something?