

# Proper fit of face masks is more important than material, study suggests

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Doctor in the fight against Ebola in Sierra Leone. Credit: [Defence Images](#)

A team of researchers studying the effectiveness of different types of face masks has found that in order to provide the best protection against COVID-19, the fit of a mask is as important, or more important, than the material it is made of.

The researchers, from the University of Cambridge, carried out a series of different fit tests, and found that when a high-performance

mask—such as an N95, KN95 or FFP2 mask—is not properly fitted, it performs no better than a cloth mask. Minor differences in facial features, such as the amount of fat under the skin, make significant differences in how well a mask fits.

The results, published in the journal *PLoS ONE*, also suggest that the fit-check routine used in many healthcare settings has high failure rates, as minor leaks may be difficult or impossible to detect by the wearer. While the sample size was small, the researchers hope their findings will help develop new fit tests that are quick and reliable, in the case of future public health emergencies. The current study only evaluated the impact of fit on the wearer of the mask—the team will evaluate how fit impacts the protection of others in future research.

The COVID-19 pandemic has made well-fitting [face masks](#) a vital piece of protective equipment for healthcare workers and civilians. While the importance of wearing face masks in slowing the spread of the virus has been demonstrated, there remains a lack of understanding about the role that good fit plays in ensuring their effectiveness.

"We know that unless there is a good seal between the mask and the wearer's face, many aerosols and droplets will leak through the top and sides of the mask, as many people who wear glasses will be well aware of," said Eugenia O'Kelly from Cambridge's Department of Engineering, the paper's first author. "We wanted to quantitatively evaluate the level of fit offered by various types of masks, and most importantly, assess the accuracy of implementing fit-checks by comparing fit-check results to quantitative fit testing results."

For the study, seven participants first evaluated N95 and KN95 masks by performing a fit check, according to NHS guidelines. Participants then underwent quantitative fit testing—which uses a particle counter to measure the concentration of particles inside and outside the

mask—while wearing N95 and KN95 masks, surgical masks, and fabric masks. The results assessed the protection to the mask wearer, which is important in clinical settings.

N95 masks—which are a similar standard to the FFP3 masks available in the UK and the rest of Europe—offered higher degrees of protection than the other categories of masks tested; however, most N95 masks failed to fit the participants adequately.

In their study, the researchers found that when fitted properly, N95 masks filtered more than 95% of airborne particles, offering superior protection. However, in some cases, poorly-fitted N95 masks were only comparable with surgical or cloth masks.

"It's not enough to assume that any single N95 model will fit the majority of a population," said O'Kelly. "The most widely-fitting mask we looked at, the 8511 N95, fit only three out of the seven participants in our study."

One observation the researchers made during their study was the width of the flange of the mask—the area of the material which comes in contact with the skin—may be a critical feature to fit. Masks which fit the greatest number of participants tended to have wider, more flexible flanges around the border.

In addition, small facial differences were observed to have a significant impact on quantitative fit. "Fitting the face perfectly is a difficult technical challenge and, as our research showed, small differences such as a centimeter wider nose or slightly fuller cheeks can make or break the fit of a mask," said O'Kelly.

Self-performed fit-checks are attractive because they save on time and resources, and are often the only method of fit testing available.

However, this study, and studies of fit-check systems in other countries, indicate that such fit-check systems are not reliable.

The researchers hope that their results will be of use for those who are working on new technologies and programs to assess fit, so that healthcare and other frontline workers are adequately protected in the case of any future pandemics. Additionally, they hope these results will bring attention to the importance of fit in clinical-grade masks, especially if such [masks](#) are to be widely used by the public. This study did not evaluate the impact of fit on protecting others, which is a future area of research.

**More information:** Eugenia O'Kelly et al. Comparing the fit of N95, KN95, surgical, and cloth face masks and assessing the accuracy of fit checking, *PLOS ONE* (2021). [DOI: 10.1371/journal.pone.0245688](https://doi.org/10.1371/journal.pone.0245688)

Provided by University of Cambridge

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