https://doi.org/10.1038/s41567-023-02044-0

The data behind the mask

By Mark Buchanan

Check for updates

A few weeks ago, I was surprised upon glancing at *The New York Times* to see a front-page article claiming that new scientific evidence showed conclusively that wearing masks does nothing to prevent the spread of the SARS-CoV-2 virus (Bret Stephens. The mask mandates did nothing. Will any lessons be learned? *The New York Times*; 21 February 2023). Even the high-quality surgical-standard N95 masks. This opinion piece by Bret Stephens reported on what he described as "the most rigorous and comprehensive analysis" of the effects of masks, published in *Cochrane Reviews*, a healthcare journal. Masks, he claimed, have no effect.

Based on everything I had read over several years, I had been of the belief that masks were somewhat effective, especially the better ones, though far from infallible. Having had this view so violently overturned, I thought I would look at the actual research to see how the authors had come to their conclusion. How strange then to find, early in the text of this meta-analysis of many other studies, the strong disclaimer that "The high risk of bias in the trials, variation in outcome measurement, and relatively low adherence with the interventions during the studies hampers drawing firm conclusions."

Never mind that, Bret Stephens drew very strong conclusions. Why? This remains perplexing to me. For many, it appears, evidence isn't something to use in forming sound opinions, but a weapon to be used — and twisted, if necessary — to help win arguments.

"For many, it appears, evidence isn't something to use in forming sound opinions, but a weapon to be used — and twisted, if necessary — to help win arguments."

Fortunately, there are still people trying to build actual knowledge about important matters, without deciding in advance what their conclusions will be. An excellent illustration is a review article (Mira L. Pöhlker et al., *Rev. Mod. Phys.*; in the press; preprint available at https://arxiv.org/abs/2103.01188) looking at what we know about the aerosols and droplets that are expelled by individuals suffering from a number of respiratory pathogens. It considers the complicated physics of how these particles are generated in the respiratory tract, how they behave in the air and how far they generally travel, as well as how well masks do in blocking their passage.

Overall, the article reports a complex and multifaceted picture of how respiratory pathogens might spread through airborne pathways. Unsurprisingly, this picture doesn't fall neatly into any strong ideological position — except, perhaps, supporting the view that the spread of infectious agents depends strongly on many details of the physical and biological environment.

I only have space to mention a few of the interesting observations. One is the typical size distribution of particles produced by an infected person when breathing, speaking, singing, or instead sneezing or coughing. As the authors summarize, studies find that the particles generated differ depending on the activity, and the output can be conveniently characterized by a set of 'normal modes' of expulsion.

One process of obvious importance is ordinary breathing, either with the mouth open or closed. For open-mouth breathing there is a roughly log-normal distribution, with particle size ranging from about 0.2 µm to just less than 1 µm, a size range in which particles can remain in the air for long periods of time. With the mouth closed, the range extends upwards to include particles with size up to nearly 10 µm. The researchers refer to these as bronchiolar breathing modes B1 and B2, and they apparently differ in the detailed biophysical mechanisms by which mucosal films get displaced by airflow and carried out of the body.

Further expulsion modes emerge from activities such as speaking and singing, which involve opening or closing of the glottis and vibration of the vocal folds in the larynx, as well as movements of mouth, lips and tongue. These activities involve five expulsion modes, which include the two breathing modes and three further modes spanning the particle size range from 10 µm to a few hundred micrometres. One of these modes is called LT, as it stems from particles formed in the larynx and trachea and covers a narrow range 0.7 and 1.5 µm. Two further oral modes, O1 and O2, involve larger droplets originating in motions of the mouth, lips and tongue. Mode O1 ranges between 8 to 13 and mode O2 from 60 to 130 µm.

One might guess that further distinct modes with even larger particles emerge from more violent coughing and sneezing, but this turns out not to be the case. As Pöhlker and colleagues describe, the experimental data for such processes shows a range of particles very similar to those created by singing and speaking, suggesting that the same dynamics are at work.

Overall, then, the spectrum of expelled particles can be well represented by a sum of five log-normal modes associated with different physiological mechanisms. Importantly, the empirical data suggests that all five of the main modes are capable of transporting small viruses such as coronaviruses or the influenza virus.

These authors also give a wealth of further data on particle number concentrations, volume concentrations and so on. But one final set of data stands out as particularly important, and relevant to the question of whether masks make any difference.

This data (shown in figure 19 of the paper) reveals the full spectrum of particles emitted from the human mouth by size, as well as available data on how this distribution is transformed upon passage through air and other barriers such as masks, leading to a final spectrum of deposition in the respiratory tract. This data shows that cheap masks, surgical masks and N95 masks all significantly reduce the number of particles reaching the respiratory tract, virtually eliminating all particles larger than 8 µm or so. Very roughly speaking, cheaper masks reduce deposited particle number by a factor of 10, and N95 masks by a factor between 10 and 100, or even 100 for larger particles.

Conclusion? Masks do have an effect. They do work, imperfectly, to stop pathogens spreading. Intuitively, I'm not in the least surprised, but it's nice to see some detailed evidence.

Published online: 15 May 2023