COVID-19 vaccines: How Pfizer's and Moderna's 95% effective mRNA shots work

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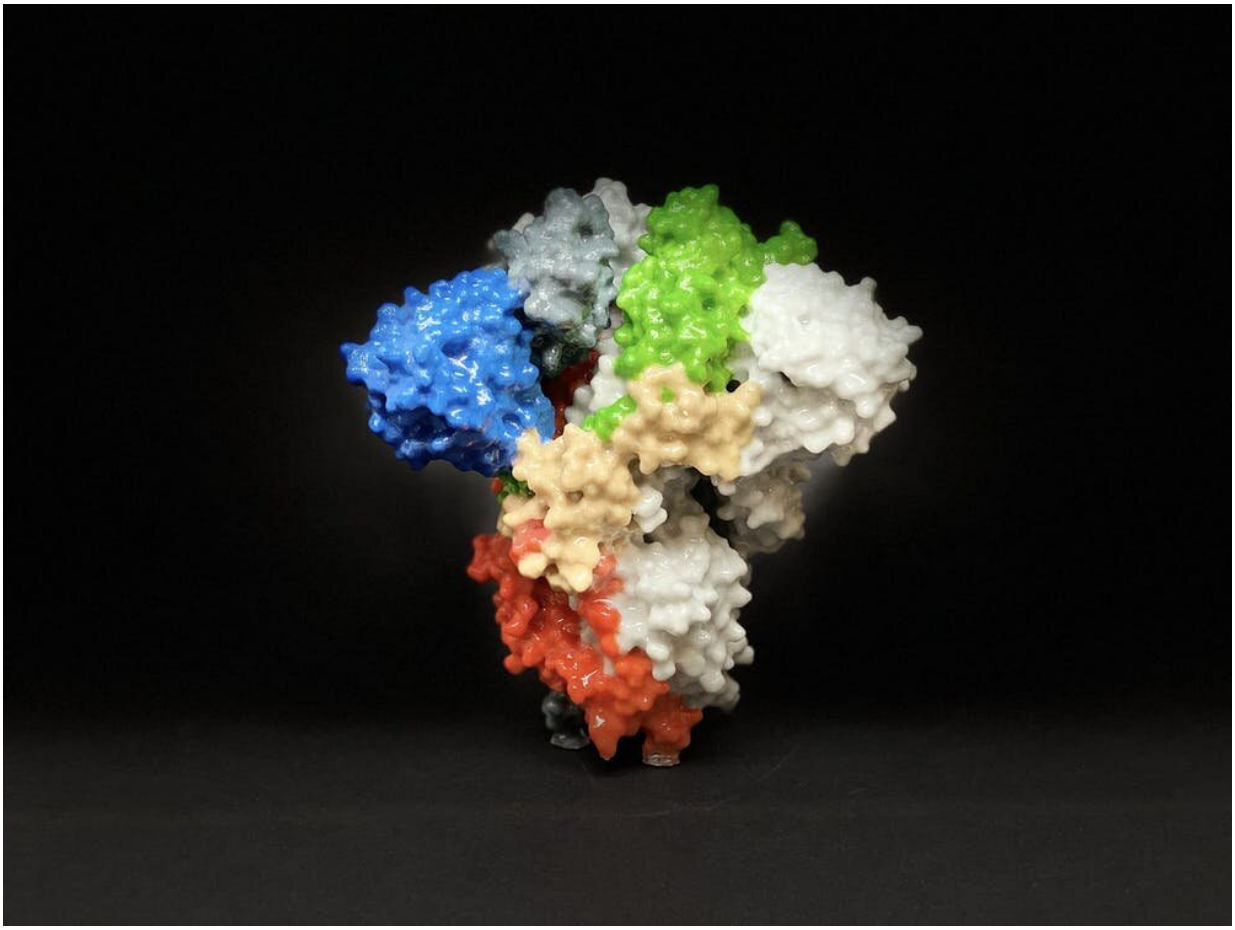

3-D print of the spike protein of SARS-CoV-2, the virus that causes COVID-19. Spike proteins cover the surface of the virus and enable it to enter and infect human cells. Credit: NIH, CC BY

The COVID-19 pandemic has driven a massive allocation of resources towards producing solutions, from identifying life-saving medications, tracking how the virus spreads and ultimately to preventing infection with vaccines.

As a physician scientist, I study how the virus has evolved over the pandemic, since any changes in the virus could also change the effectiveness of current treatments. On Nov. 9, Pfizer announced preliminary trial results showing that a vaccine it developed with BioNTech was about 90 percent effective. That was followed up nine days later with final trial results and two months of safety data, indicating a 95 percent effectiveness rate.

Pfizer announced on Nov. 18 that it intends to file for emergency authorization with the U.S. Food and Drug Administration.

Meanwhile, on Nov. 16, Moderna announced preliminary results for its own vaccine, developed with the U.S. National Institutes of Health, which also indicated effectiveness of about 95 percent.

This is good news, but we need to understand what it means so life can ultimately go back to normal.

DNA, messenger RNA and proteins

Both Pfizer's and Moderna's vaccines are mRNA-based. In each of our cells, DNA produces messenger RNA (mRNA) containing the templates for making proteins. It's called messenger RNA because it carries that information to other parts of the cell, where the instructions are read and followed to produce specific proteins.

When a patient is injected with mRNA in a vaccine, their cells use the information in that mRNA to create a protein: in this case, a version of

the spike protein from the coronavirus that causes COVID-19. The immune system recognizes that protein as a signal to produce antibodies and immune cells.

An mRNA vaccine has some advantages for mass vaccination. It can produce robust immunity, can be made rapidly at low cost, and, like inactivated and subunit vaccines, it is impossible for it to cause someone to develop the illness.

Building immunity

This vaccine has the potential to protect many people from this devastating virus. When it is said that a vaccine is 90 percent effective, this means that if 100 people received the vaccine and were then exposed to the virus, 90 would be unlikely to get sick. While 10 would be at risk of still developing the infection, fortunately protection from vaccines is not all-or-nothing. These 10 individuals could have milder disease than someone who did not receive the vaccine.

It takes time for immune systems to prepare to fight infections. Think of building immunity to SARS-CoV-2, the virus that causes COVID-19, like preparing to run a marathon. First, the runner must register, just as the immune system must be exposed to the infectious agent. Then, they need to build stamina. For the immune system, this means making antibodies and immune cells. Finally, they run the marathon: the bolstered immune system now removes the infectious agent from the body, or prevents it from doing further damage.

In both the Pfizer and Moderna clinical trials, subjects received the vaccine in two doses, three or four weeks apart, respectively. That's about how much time it takes for the stimulated immune system to produce meaningful protection. A booster vaccine was given to produce even more antibodies and immune cells. In terms of the marathon

example, this is like doing a practice marathon around three weeks into training. The runner will do better than they would have on day one, but more training is likely still needed. The booster vaccine provides that extra training.

The beginning of the end

Should we expect the pandemic to be over once a vaccine is available for public use? Not exactly. A vaccine will not be perfect, and it takes time for the immune system to be ready to protect us.

In addition, it is possible that the vaccines will be less effective than cited. Clinical trials are carefully set up, but it is possible that the virus will have evolved enough since the vaccines were designed so they will provide less benefit. It will also take time for enough vaccine to be made and administered for the population to achieve herd immunity.

Masks and social distancing will still most likely be necessary throughout 2021 because it takes time to accomplish such large-scale projects. We cannot expect herd immunity from our neighbors getting sick to get the world back to normal, even while neighbors are receiving vaccines. The human cost is unacceptable and the virus is too infectious for this to produce meaningful results unless 67 percent of the population is infected, with a lot of people dying up to that point and afterwards.

We are in a scary time but have reason to have hope. The news of the Pfizer and Moderna vaccines is good news and could potentially bring the world back to something more normal. We must not forget that it will take time and all of us working together. Masks and social distancing are our reality right now, and will remain so until at least next year. We must persevere with these measures, even when we find them frustrating. There is a light at the end of the tunnel and we can all reach it if we work together.