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COVID-19 Vaccines: (almost) everything you need to know

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If there is one thing that everyone has been talking about in 2021, it is vaccines. It has been quite a year – with the science advancing so quickly, there have been many new accomplishments. The year has seen the first ever mRNA vaccine get approval for public use after being developed and evaluated in less than 10 months, making it the quickest vaccine to ever be created.

There have been huge clinical trials completed in record time for all approved vaccines, and the UK has become the first country in the world to approve and start delivering COVID19 vaccines. As of today, there are three vaccines approved for use in the UK, manufactured by Pfizer-BioNTech, Oxford-AstraZeneca and Moderna. This article explores some important topics regarding COVID19 vaccines and debunk conspiracy theories that may be preventing people from getting vaccinated.

Why is a vaccine against SARS-COV2 so important?

Controlling the spread of COVID19 in an ethical manner is ultimately dependent on mass vaccination – this is the only way the world can return to some degree of normalcy without resulting in excessive fatalities. Vaccines are highly effective in preventing infection with SARS-Cov2 (the virus that causes COVID19) and getting vaccinated also provides protection to the people around you. Also, even if the vaccine does not prevent infection, it can effectively prevent serious illness in the incidence of infection:

This explains why the first group to be offered vaccinations in the UK have been the elderly, as they are most at risk of severe disease and death. Reducing the amount of severe COVID19 cases is important because it reduces the strain on the NHS by keeping the number of patients at a manageable number.

Are all the COVID19 vaccines the same?

No! The technologies used in the three currently approved vaccines are quite different. The Pfizer-BionNTech vaccine and the Moderna vaccine are mRNA vaccines – for an explanation of how these work, see the article ‘Pfizer-BioNTech COVID-19 vaccine explained’ by Nadia Patel in Issue 1 of Bioscientist Magazine.

The Oxford/Astra Zeneca vaccine is a “viral vector” vaccine in which a harmless adenovirus is genetically modified so that it expresses the SARS-CoV2 spike protein on its surface. When this is injected into the muscle of the upper arm, it fools the body into thinking that it is being attacked by SARS- CoV2 which triggers a strong immune response. Adenovirus vectors are quite new but have previously been used successfully in a vaccine against Ebola virus, and vaccines against Zika virus and HIV using this technology are in development.

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Are the current vaccines any good?

At present, only the Pfizer-BioNTech and Oxford/AstraZeneca vaccines are in widespread use in the UK; the Moderna vaccine should be rolled out until next month. All these vaccines have been rigorously tested before being approved, firstly to make sure they do not do any harm and secondly, to quantify how good they are at preventing infection and disease.

The outcomes of these clinical trials were encouraging, if a bit confusing. Clinical trials for the Pfizer-BioNTech vaccine involved 43,000 people (which is much bigger than usual) and indicated that it had an efficacy rate of 95%, which means the proportion of vaccinated people in the trial who got SARS- CoV2 infections was 95% lower than the proportion of unvaccinated people who got infected. These results were very promising. However, protection against symptomatic COVID19 was even better – only one person among the 1000s who were vaccinated got severe COVID19.

The performance of this vaccine in the “real- world” has also been proven; a huge study (1.2 million people!) conducted in Israel showed that two doses of the Pfizer-BioNTech vaccine cut symptomatic cases by 94% across all age groups, and severe illness by nearly as much. The study also showed that a single shot of the vaccine (a strategy currently used in the UK) was 57% effective in protecting against symptomatic infections. Clinical trials of the Oxford/AstraZeneca vaccine, which involved about 12,000 people, indicated an efficiency rate of 70% in term of protecting against infection and, importantly, none of those vaccinated developed severe COVID that required hospitalisation.

So, overall, these vaccines are good at stopping you from becoming ill and, because they also reduce the risk of people being infected and therefore infectious, they are having a positive impact on the epidemiology of the COVID19, curbing the pandemic.

What are the clinical trials?

There has been some uneasiness about the speed with which the COVID19 vaccine trials were completed - so does this mean that they cut corners? To evaluate this, the mechanisms of these trials need to be considered: There are three phases to a clinical (i.e. human) trial, but before these can start, new vaccines are tested in the laboratory.

In Phase I, the vaccine is given to a small group of adult volunteers (around hundred) to see if it generates an immune response and to make sure there are not any unexpected side-effects. In Phase 2, the vaccine is administered to a larger number of volunteers (several hundreds) and monitored for possible potential side effects and to ensure an immune response is generated consistently in all people, regardless of age and sex. In Phase III, thousands of volunteers are recruited (see above), with about half of participants receiving the vaccine and half a placebo, allowing thorough assessment of the vaccine’s efficiency.

The outputs of phases 2 and 3 must provide evidence of successful prevention of the disease if the vaccine is going to be approved for use. This approval is not given by politicians, but by an independent group of scientists called the Medicines and Healthcare Products Regulatory Agency. They carefully review all the data from clinical trials before deciding if the vaccine is both effective and safe.

The time taken to trial and approve COVID19 vaccines seemed like a short period, but this was made possible because unprecedented resources were provided for the process. It is truly incredible to witness the achievements of readily available funding combined with willpower and collaboration.

What are the barriers to vaccine roll out?

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By the end of February about 30% of the population of the UK will have received at least one dose of a COVID19 vaccine – that is about 20 million people! Despite this success, there are many reports of people refusing the vaccine, so why is this?

Firstly, many people fear injections – a fear which is termed “trypanophobia” and affects about 10% of people. However, most vaccine refusers appear to worry about the safety of the vaccine, particularly that it may have long-term side effects that are not yet recognised. These fears are heightened by the fact that both vaccines use relatively new technology. (mRNA and adenovirus vectors).

However, history can testify that vaccines in general are safe – billions and billions of people around the planet have been vaccinated against a range of diseases! In the UK, millions of adults get flu vaccines every year, so maybe 20 or 30 in their lifetime, with no side effects. And this vaccine has been used for about 70 years now, without long-term side effects emerging.

The health authorities constantly monitor COVID19 vaccinations to check for side effects through the “yellow card system”. The most recent analysis of these data, based on 5.4 million people who received their first dose of Pfizer-BioNTech vaccine, showed that about 17,000 “yellow cards” had been reported, but only for side effects such as a sore arm, headache, fatigue etc. These symptoms, and the rate at which they have been reported, are no different to those for other well- accepted vaccines.

Conspiracy theories are also hindering vaccine roll-out. The theory that is currently gaining most attention is that vaccination could cause infertility. This theory is based on apparent similarity between the SARS-CoV2 spike protein and syncytin-1, a protein found in the placenta, and theorises that antibodies produced against the spike protein in vaccines will cross-react with syncytin-1 and provoke immune-mediated damage to the placenta. However, a closer look at the apparent similarity between the two proteins reveals that it is nowhere near sufficient to provoke immunological cross-reaction. Indeed, there are numerous other proteins in the body such as collagen and haemoglobin that are just as similar to the spike protein as syncytin-1 (i.e. not very).

Conspiracy theories about vaccines are not new - the most infamous is the Andrew Wakefield study in the 1990s that linked the MMR vaccine to autism. Although this study has been repeatedly disproven, and Wakefield “struck off” after being shown to have misrepresented his data, media coverage of his claims provoked widespread vaccine refusal that resulted in the re-emergence of measles, mumps and rubella in the UK, with some fatalities – highlighting the harm conspiracy theories can have if they are amplified by popular newspapers or social media.

SARS-CoV2 is an RNA virus, which means its genetic information is stored on RNA (not DNA like in most organisms. The enzyme that copies RNA during reproduction is far less accurate than the enzyme that copies DNA, so RNA viruses have very high mutation rates that lead to lots of genetic variation occurring very quickly.

Knowledge on the diversity of SARS-CoV2 is readily available because many countries have been sequencing viral genomes. It is also known that 1000s of mutations have occurred over the last 12 months. However, most of these mutations do not affect the behaviour of the virus – but there are some important exceptions that are referred to as “variants.”

Mutations have occurred in the genes of these variants which encode the spike proteins. This result is the production of spike proteins with an altered shape, making the variant more transmissible and/or more efficient at invading cells in the lungs.

The two most infamous variants are the Kent variant (B.1.1.7) and the South African variant (B.1.351).

The SARS-CoV2 spike protein is the target of human antibodies that mediate the immune system killing the virus, and it may be that some antibodies produced in response to the vaccine will not recognise the variant spike protein, resulting in a potential decrease in the effectiveness of the vaccines against these variants. Results of early studies addressing this possibility for the Kent and South African variants suggest the efficiency current vaccines may indeed be compromised, particularly against the South African variant.

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So, does this mean that vaccination will soon be worthless? Not really, but it does mean that a vaccine-based strategy for controlling COVID19 requires seasonal/annual boosters. These boosters can be re-engineered to match whatever SARS- CoV2 variants are dominant each year, just as happens now with the flu vaccine. The technology to do this re-engineering is already available, so this strategy should not be a problem. The challenge is simply accepting the notion that that life will have to continue alongside SARS-CoV2, rather than eradicate it completely.

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