European Journal of Immunology

News & EFIS

COVID-19 vaccines – common misperceptions, false claims and myths explained

Carsten Watzl is an immunologist, appointed professor at the University of Dortmund, Secretary General of the German Society for Immunology and Editorial Board member of the *European Journal of Immunology*. During the SARS-CoV-2 pandemic Carsten became known to the broader public through his Twitter activities, frequent interviews in the newspapers and appearance in a number of talk-shows. According to Carsten, it all started one afternoon in December 2020 when journalists from the *Heute Journal* asked him to comment on the upcoming approval of mRNA vaccines. This was also a period of the first public debates about the benefits and risks of vaccination, and also a time when media began to recognize the importance of immunology as a discipline to combat the pandemics. An interesting and fun fact is that from then on, Carsten participated in over 500 interviews and achieved a record of 11 interviews in a single day.

In this article, Carsten will flag common public misconceptions about SARS-CoV-2 and vaccinations, contrasting these with scientific evidence, from perspective of an immunologist.

1. **COVID-19 vaccines affect fertility in younger women**

The false claim that COVID-19 vaccines could in any way affect fertility is nothing new. Similar claims have been made against other vaccines. In 2003 for example the Polio vaccination campaign was boycotted in northern Nigeria due to claims that the vaccine could affect fertility [1]. More recently, similar claims were raised against the HPV vaccine, which protects against cervical and other papilloma virus-induced cancers. In every instance these claims were proven to be wrong! In case of the COVID-19 vaccines, even a mechanism was proposed, suggesting a similarity between the spike protein of SARS-CoV-2 and syncytin-1, a protein found in the placenta. However, not only is this similarity so weak that it cannot cause any cross-reactivity [2], but there are also numerous studies clearly showing that:

- COVID-19 vaccines have no effect on female or male fertility (whereas SARS-CoV-2 infection can negatively affect sperm quality in men) [3].
- They are as safe and effective in pregnant women as they are in non-pregnant women [4].
- Vaccination during pregnancy can protect babies for the first months after birth from hospitalization with COVID-19 [5], and during nursing protective antibodies but not the vaccine can be transmitted to the baby.

Even in light of this overwhelming evidence demonstrating the safety and the benefit of the COVID-19 vaccines, which is beautifully summarized by Viki Male (Imperial College London) [6], these false claims still result in vaccine hesitancy. This may be explained by the fact that reproduction is such a basic evolutionary need that even completely baseless claims can have a strong negative effect.

2. **Natural immunity is better than vaccination**

Because of immunological memory, prior infections can induce immunity. This is also the case for a SARS-CoV-2 infection, but I would not call the immunity after an infection with a pathogenic virus 'natural'. This is exactly the process that is utilized by the vaccines. However, the big difference is that vaccines induce this immunity without the pathology that can be induced by the infection. While vaccination can also induce side effects in very rare cases, it is clear by now that the risk that is associated with vaccination is much lower than the health risk of a SARS-CoV-2 infection [7, 8]. While this difference is of course much greater in the elderly, the benefits of vaccination still outweigh the risks even in children. Therefore, immunity by infection comes with a greater risk than immunity by vaccination. But is the immunity after an infection better? The decay of neutralizing antibody levels is slower in individuals after a SARS-CoV-2 infection compared to vaccination [9]. And the immune system responds to all antigens of the virus during an infection, whereas only spike-specific responses are induced by most vaccines. Therefore, immunity after infection can have its benefits. But it is not sufficient! After an infection with variants prior to omicron, individuals have very few if any antibodies that can neutralize the omicron variant. Vice versa, an infection with omicron does not provide good protection against other variants of the virus. The best form of immunity currently known is 'hybrid immunity', a result of vaccination AND infection. Three exposures to the antigen are necessary to provide basic, long-lasting immunity against SARS-CoV-2 [10], but an infection, preferably after vaccination, can only replace ONE vaccine dose.

3. **Vaccines can change the genome of a vaccinated individual**

This is another myth that is directed against the basic evolutionary need of genomic integrity. It is stimulated by the fact that the mRNA vaccines are based on genetic material and that the vector vaccines utilize a genetically engineered virus. In simple terms: The likelihood that an mRNA vaccine integrates into the genome of cells in your body is just as low as the

likelihood for one of the many thousands of mRNAs that are constantly present in your cells to alter your genes. If there were any elevated risks for mRNAs to alter the genetic material of a cell, we would constantly see mutations and cancers caused by this. Similarly, the risk for an adenovirus-based vaccine to alter your genes is just as low as the risk that your next common cold, an infection often caused by adenoviruses, would do so. But these simple explanations often don't convince people. There are even publications, trying to show integration of mRNA vaccines into the DNA. However, even when one exposes a liver cell line *in vitro* to concentration of an mRNA vaccine that would never be reached *in vivo*, one may be able to find some evidence that mRNA could be reverse transcribed into DNA, but no evidence of integration into the genomic DNA could be shown [11]. Additionally, more than one year after the first mRNA or vector-based COVID-19 vaccines were introduced and after administration of billions of doses there is no indication that these vaccines would alter your genes. In contrast, the genetic material of SARS-CoV-2, which is an RNA virus, can be reverse transcribed and has been shown to integrate into the genome of infected cells in some individuals [12].

4. **If vaccines work, why was I infected after vaccination?**

During an infection, B cells and T cells that can recognize the pathogen start to proliferate and to build up a large army that will fight the invader. After the infection is cleared and the antigen is gone, many of these cells will die, as it would be non-economical for the immune system to keep all these cells around. Only a few cells survive in form of memory cells. As already mentioned, vaccines induce a similar immune response as an infection does. Also, after vaccination, many of the antibody-producing cells will die. Therefore, antibody titers typically drop quite fast within the first months after vaccination. However, they stabilize to a long-lasting antibody titer that is maintained by antibody producing memory cells. While such a long-lasting titer may be sufficient to protect against an infection with measles for many decades, you need quite high antibody titers to be protected from a respiratory infection such as with SARS-CoV-2. As omicron carries so many mutations in its spike protein, many of the vaccine-induced antibodies cannot recognize this variant, which is the main reason why protection from infection, especially with omicron, is not optimal and is waning with time. However, the vaccines still protect from severe disease if you do get a breakthrough infection, as this protection is mediated by long-lived memory cells. Therefore, vaccines do work, also against omicron, as they protect against severe disease!

5. **If vaccines work, why do I need frequent boosters?**

Repeated exposure to an antigen can re-activate memory cells and start a process called affinity maturation, where immunity not only gets stronger, but also better. This is the reason why antibody titers after the third COVID-19 vaccination are much higher than after the second shot, and are better equipped to neutralize different variants, including omicron. Therefore, the basic vaccination protocol to protect against COVID-19 consists of three vaccine doses. Of course, this protection will not last a lifetime and especially vulnerable populations may need annual booster doses for continued protection. But for most healthy individuals this basic immunity maybe all they need to protect them against severe COVID-19 and they will most likely refresh their immunity by mild SARS-CoV-2 infections.

6. **Coronavirus is just another respiratory virus similar to influenza virus**

Similar to influenza, age is a major risk factor for a SARS-CoV-2 infection. However, the big difference between these two viruses is that almost no one had any pre-existing immunity against SARS-CoV-2, which resulted in a much higher case-fatality rate in the first year of the pandemic. While the current omicron variant has lower intrinsic pathogenicity compared to previous variants, future variants may again be as pathogenic as the delta variant. Therefore, it is not the virus that necessarily changes to become less dangerous. We must change! And we are slowly changing, mostly by vaccination-induced immunity. Through this change we may reach a state in the future, where SARS-CoV-2 is indeed only as dangerous as the flu. But when people make this comparison, they often try to argue that vaccinations or other non-pharmaceutical interventions such as social distancing and masks are not necessary. And without vaccinations, SARS-CoV-2 would remain much more dangerous than the influenza virus for many years to come.

7. **Children do not need to be vaccinated because they develop mild disease**

In my opinion it is not absolutely necessary to vaccinate children, but it is very good that we have this option. Luckily, healthy children have a very low risk of developing severe COVID-19. But this risk is also not zero, as about 1 in 10.000 otherwise healthy children need to be hospitalized with severe COVID-19 and 3 in 10.000 infected children will develop a paediatric inflammatory multisystem syndrome (PIMS), and half of them will need to be admitted to the intensive care unit with this condition. In contrast to this, the risk of vaccinating children is also very low – a mostly mild myocarditis affecting 1 in 12.000 vaccinated males 12–17y being the greatest risk (it is much lower for males 5–11y and there is no increased risk for females in this age group). So simply looking at these numbers it is less of a risk to vaccinate your child as the vaccines protect from severe disease and from PIMS. However, as vaccination and infection carry such a low risk, there are no wrong decisions. But one must be clear that the only choice a parent has is to decide if the child gets infected with SARS-CoV-2 with the protection of vaccines or without.

8. **All currently approved vaccines were developed fast, so their safety is questioned**

The development of COVID-19 vaccines did not start with the emergence of SARS-CoV-2. It was based on decades of research. Take for example the mRNA vaccines where prior research had already established how the RNA needed to be designed to provide efficient production of the antigen. It was known that the RNA needed to be modified so that it would not overly stimulate the innate immune system. The formulation of the lipid nanoparticles was optimized not only to protect the mRNA cargo, but also to deliver it directly to antigen-presenting cells. Prior research into SARS and MERS had already established how a vaccine could protect from the novel corona virus, that the spike protein had to be used as an antigen and that specific mutations within this spike protein could stabilize it in a form that best induced neutralizing antibodies [13]. All

this prior knowledge, combined with the ability to quickly adapt the mRNA technology to a new antigen made it possible to develop vaccine candidates within weeks after SARS-CoV-2 first emerged. But also the testing of these vaccine candidates was much faster. Not because critical safety steps were omitted. Regulatory authorities sped up their approval and review process and the pharmaceutical companies were able to recruit phase 3 trials of up to 40.000 participants within weeks because many people were interested in participating in these trials. Typically, recruiting so many participants in a vaccine trail can sometimes take years. And finally, the number of infections needed to determine the efficacy of the vaccines was quickly reached, as the trials took place in countries and at a time with high SARS-CoV-2 infection rates.

All these are explanations for the fast development of the COVID-19 vaccines. But did it compromise safety? Vaccines can have unwanted side effects. They are caused by the immune reaction which is induced by the vaccine. As these immune reactions take place within weeks after vaccination, this is the time frame where unwanted side effects can occur. The phase 3 studies had safety data for up to two months after the last vaccine dose, which would be sufficient to detect possible side effects. And these studies were very large compared to other vaccine trials, thereby enabling the detection of more uncommon events. But as side effects are often very rare, they are mostly detected upon vaccinating millions of people after approval of the vaccine. Therefore, it is a strength of the COVID-19 vaccines, that they were administered to many people within a short time frame. This made it possible to quickly detect very rare side effects that only affect less than one in 100.000 vaccinated individuals. In essence, we know more about the safety of the COVID-19 vaccines than about many other vaccines within the same time frame.

Outlook

As vaccines are given as a prophylaxis to healthy individuals, they not only need to be especially safe, but vaccine uptake is very much dependent on trust. As evident by the examples mentioned in this article, it is very easy to undermine this trust even with completely unfounded or even false claims. Therefore, open and effective communication about vaccine safety and efficacy is essential. Maybe some of the arguments mentioned here can help you when talking to people who have been exposed to vaccine critical claims and are therefore hesitant.

While the COVID-19 pandemic has certainly exposed the problem of people who strongly oppose vaccinations, it also has sparked a lot of public interest into the subject of vaccines. Therefore, future developments of novel vaccines such as a pan-coronavirus or pan-influenza vaccine, or novel application routes such as mucosal immunization have gained public interest. It is up to us scientists to continue to educate the public about the benefits of vaccines as one of the greatest achievements of immunology.

Carsten Watzl

Department for Immunology, Leibniz Research Centre for Working Environment and Human Factors (IfADo) at TU Dortmund, Dortmund, Germany

References

1 **Jegede, A. S.**, *PLoS Med* 2007. **4**: e73.
2 **Prasad, M., et al.**, *Cell Mol Immunol* 2021. **18**: 2566–2568.
3 **Wesselink, A. K., et al.**, *Am J Epidemiol* 2022.
4 **Dagan, N., et al.**, *Nat Med* 2021. **27**: 1693–1695.
5 **Halasa, N. B., et al.**, *MMWR Morb Mortal Wkly Rep* 2022. **71**: 264–270.
6 **Male, V.**, Explainer on COVID vaccination, fertility, pregnancy and breastfeeding. https://drive.google.com/file/d/1_wHIYX-tGkGBPwuax7N8BxZPR4PTTCDm/view.
7 **Male, V.**, *Nat Rev Immunol* (2022). https://doi.org/10.1038/s41577-022-00703-6.
8 **Barda, N., et al.**, *N Engl J Med* 2021. **385**: 1078–1090.
9 **Urlaub, D., et al.**, *Eur J Immunol* 2022.
10 **Wratil, P. R., et al.**, *Nat Med* 2022.
11 **Aldén, M., et al.**, *Current Issues in Molecular Biology* 2022. **44**: 1115–1126.
12 **Zhang, L., et al.**, *Proc Natl Acad Sci U S A* 2021. 118.
13 **Dolgin, E.**, *Nature* 2021. **597**: 318–324.

Full correspondence: Carsten Watzl, Department for Immunology, Leibniz Research Centre for Working Environment and Human Factors (IfADo) at TU Dortmund, Dortmund, Germany.
e-mail: watzl@ifado.de

