COVID-19: Debunking the Anti-Vaxxer Rhetoric

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Abstract

COVID-19 emerged at the end of 2019 and is caused by the SARS-CoV-2 virus. Vaccines were released into the market towards the end of the year 2020. This has caused an “anti-vaxxer” uproar that is unprecedented in our modern times questioning the validity as well as necessity of related scientific research. People all around the world, despite having been vaccinated against multiple pathogens in the past, seem to be worried about these emerging vaccines. Several claims have been circulating among the general public; people are spreading rumors based on shallow research at best to justify an irrational fear of the unknown. In this review article, we aim to examine these claims and respond to them, using scientific evidence and historical facts.

Introduction

In the age of the internet, information has never been as easily generated and shared on online platforms than ever before. This serves as a blessing for scientific data in terms of its accessibility to the general public, but also a curse through the potential of spreading false information to millions of people. This phenomenon is neither recent nor exclusive to the Covid-19 global outbreak, but in a state of global pandemic, the promotion of false information could have detrimental effects on the lives of millions.

Novel coronavirus SARS-CoV-2, which has been designated as COVID-19 by the World Health Organization (WHO) on the 11th of February 2020 is a member of the β-coronavirus family that is highly pathogenic for humans (1). Since its emergence in Wuhan, China in December 2019, Covid-19 has terrorized the world and infected over 85 million people with a mortality rate of 2% (1). The disease causes an acute respiratory syndrome that is most commonly associated with a dry cough, fever, and shortness of breath as well as other less common symptoms such as body pain, loss of smell and taste, and gastrointestinal complications (1). The viral structure consists of an enveloped RNA genome of 27 to 32kb in length as well crown-shaped spikes that span the surface of the virus from which the name was derived (1). Transmission of the disease occurs through these spikes primarily following contact with a positive case or through droplet transmission (2). However, evidence also suggests that transmission could also be airborne or via fomites, which are surfaces that could host the virus for a certain period of time (2).

Although several measures such as social distancing and the use of masks have been implemented on at the international level combined with the use of antiviral therapeutics to treat positive cases, the need for a vaccine remains of utmost priority to prevent the further spread of the virus in order to stop the pandemic and go back to pre-pandemic normal life. However, due to the influence of the "anti-vaxxer" community, which might be heavily influenced by misinformation concerning the use of vaccines, the use of a vaccine for Covid-19 has been the subject of international dispute. This commentary will provide insights into the fears present among the general public surrounding the Covid-19 vaccine by dissecting the factors that have led to its emergence and providing scientific support for the importance of vaccination at this point in time

"It was developed too fast"

One of the main suspicions the general public has concerning the vaccine is the fact that it was developed "too fast." To say that it was developed too fast is to disregard the factors that contributed to this process, namely those of urgency and funding.

Traditionally speaking, vaccine development requires years if not decades to complete given the laborious process of moving from preclinical investigation to clinical studies (3). A major element that often precludes this transition is the bureaucracy of the FDA in which all the data generated in the preclinical phases of development must be reported in full detail before product development is allowed to progress (3). Following development, it typically takes 6 to 10 months for a medication or vaccine to be marketed due to similar bureaucratic delivery of data to regulatory agencies (3).

In the case of Covid-19 however, information has been delivered to these agencies on a rolling basis due to the urgency of the pandemic. Furthermore, the Pfizer vaccine has been granted emergency use authorization (EUA) by the FDA (4). EUA is a mechanism established by the FDA in 2004 that enables the authorization and use of unapproved medical countermeasures in times of public health emergencies, as is the case with the Covid-19 pandemic (5). EUA serves as a tool for physicians to detect, treat, and prevent serious disease or injury based on certain criteria when no adequate alternatives are available (5). Upon submitting the request for EUA, the FDA thoroughly assesses the provided evidence and makes its decision accordingly. One of the required criteria is testing, and testing is often determined by the available population of patients (5).

Since its emergence, Covid-19 has affected millions of people, thereby providing sufficient pools of patients that consist of hundreds of thousands to adequately investigate the vaccine (6). In addition, people tend to overlook the fact that Covid-19 is structurally and functionally similar to SARS and MERS, which facilitated the jump from preclinical testing on animals to clinical testing on humans (7). This rigorous testing generates the necessary scientific data for approval.

An example of EUA is that issued in response to H1N1 in 2009 (5). Prior to that, one EUA was issued for a medication used to treat anthrax inhalation and another was issued for emergency antibiotic kits in 2008 which to this day is still in effect (5). Yet another EUA had been issued for N95 respirators, three for antiviral medications, and nine for in vitro diagnostics (5). EUA is not a novel strategy for crisis control, nor is it uncommon. The EUA for Covid-19 vaccines is a well-studied and appropriate response to the magnitude of this deadly viral infection.

Incidentally, outside the context of emergency approval, drug development process has been, in many cases, accelerated as was observed with the anti-cholesterol drugs, statins which was approved in 1986 and progressed into commercial use by 1987 (8).

Another major factor that influences drug development is funding. Although the technology for development is present and in use, the process is costly and heavily correlated to the contemporary trends in science. *The Lancet Global Health* has reported that the cost of early development and preclinical testing falls within the range of 31–$68 million (9). Given its impact on the economy, it is within both public and private interest to research Covid-19. This has not only led to the emergence of hundreds of vaccine candidates, some of which are undergoing fast-tracking, but also to the convergence of public and private funds towards the development process in which billions of dollars have been allocated (10).

Also, a baseline work over the past 10 years has been going on in regard to the use of mRNA in the development of vaccines. It is not a new methodology. This is because it is easier to replicate and manufacture in large quantity rather than using the methodology of culturing the virus itself which is tedious and time consuming not to mention expensive since it requires special cells to grow the virus. As to using vectors like adenovirus, this is also an old methodology used in cancer treatment.

So, was the vaccine developed too fast? Yes but this does not preclude it being equally tested and equally safe. This observed speed of development, as discussed above, is an adequate

response given the global state of emergency as well as the constant flow of funding that have made it possible for both the public and private sector to ensure the safe development and delivery of the Covid-19 vaccine.

“It can alter your genes.”

There seems to be an emerging fear of the developed Covid-19 vaccines hidden under the guise of a more general fear of mRNA vaccines. The truth of the matter, however, is that mRNA vaccines are not new technology that is being implemented for the first time.

The first reported successful case of delivering mRNA into organisms was in 1990. Wolff et al. reported trials of gene transfer directly into murine muscle tissue in vivo (11). Five years later, J Ross reported optimizations to the technology that can confer stability to mRNA injections, which was one of the primary concerns surrounding their efficacy (12). Ever since, mRNA vaccines have been used to treat an array of diseases including different types of cancer (13).

mRNA, or messenger RNA, is the molecule that DNA is transcribed into that leaves the nucleus where DNA is found and is destined to reach ribosomes in the cytoplasm. There, mRNA is translated into proteins. That is how your DNA, essentially, codes for proteins.

The fear resides in the relationship between DNA and RNA and their interaction. However, is this fear valid? The short answer would be no. The long answer is that while mRNA that is synthesized in the nucleus can leave it to head towards ribosomes, it cannot travel from the cytoplasm into the nucleus. For this reason, mRNA introduced into your body through a vaccine

will not even be within the same vicinity as your DNA (13). Another reason why mRNA vaccination is safe is the short half-life of mRNA. After the molecule is metabolized in the cell, it can no longer code for proteins (13).

“It gives you Corona disease”

A common misconception circulating among the general public is that the mRNA in the vaccine will code for the viral particle itself. In reality, what the mRNA codes for is specific antigens that are sufficient to trigger an immune response, without coding for the whole array of proteins needed to make up the virus. For example, the mRNA-1273 vaccine, developed by Moderna codes specifically for the spike protein S-2P, which is a key antigen of the viral particle (14). The Pfizer vaccine, BNT162b2, also codes for the spike protein and similarly aims to immunize the body against this antigen (15).

What these vaccines basically do is introduce the mRNA coding for the spike antigen into your body. Your cells will synthesize this protein and nothing else. Your immune system will detect the protein, familiarize itself with it, and prepare itself to fight it the next time it encounters the same antigen, which happens when a person gets infected with the actual virus.

“What does the vaccine contain?”

In a world of never-ending scientific progress, there remains a fear of “chemicals” among the general public. Especially in the context of vaccines, a lot of people express concerns about the chemical composition of vaccines stemming from certain claims that such vaccines contain harmful chemicals and even trackable microchips.

Let us consider the two ingredient lists presented in the table below:

List 1	List 2
INGREDIENTS: mRNA, LIPIDS ((4-HYDROXYBUTYL)AZANEDIYL)BIS(HEXANE-6,1-DIYL)BIS(2-HEXYLDECANOATE), 2 [(POLYETHYLENE GLYCOL)-2000]-N,N-DITETRADECYLACETAMIDE, 1,2-DISTEAROYL-SN-GLYCERO-3-PHOSPHOCHOLINE, AND CHOLESTEROL), POTASSIUM CHLORIDE, MONOBASIC POTASSIUM PHOSPHATE, SODIUM CHLORIDE, DIBASIC SODIUM PHOSPHATE DIHYDRATE, AND SUCROSE.	**INGREDIENTS:** WATER (75%), SUGARS (12%) (GLUCOSE (48%), FRUCTOSE (40%), SUCROSE (2%), MALTOSE (<1%)), STARCH (5%), FIBRE E460 (3%), AMINO ACIDS (<1%) (GLUTAMIC ACID (19%), ASPARTIC ACID (16%), HISTIDINE (11%), LEUCINE (7%), LYSINE (5%), PHENYLALANINE (4%), ARGININE (4%), VALINE (4%), ALANINE (4%), SERINE (4%), GLYCINE (3%), THREONINE (3%), ISOLEUCINE (3%), PROLINE (3%), TRYPTOPHAN (1%), CYSTINE (1%), TYROSINE (1%), METHIONINE (1%)), FATTY ACIDS (1%) (PALMITIC ACID (30%), OMEGA-6 FATTY ACID: LINOLEIC ACID (14%), OMEGA-3 FATTY ACID: LINOLENIC ACID (8%), OLEIC ACID (7%), PALMITOLEIC ACID (3%), STEARIC ACID (2%), LAURIC ACID (1%), MYRISTIC ACID (1%), CAPRIC ACID (<1%)), ASH (<1%), PHYTOSTEROLS, E515, OXALIC ACID, E300, E306 (TOCOPHEROL), PHYLLOQUINONE, THIAMIN, COLOURS (YELLOW-ORANGE E101 (RIBOFLAVIN), YELLOW-BROWN E160a), FLAVOURS (3-METHYLBUT-1-YL ETHANOATE, 2-METHYLBUTYL ETHANOATE, 2-METHYLPROPAN-1-OL, 3-METHYLBUTYL-1-OL, 2- HYDROXY-3-METHYLETHYL BUTANOATE, 3-METHYLBUTANAL, ETHYL HEXANOATE, ETHYL BUTANOATE, PENTYL ACETATE), 1510, NATURAL RIPENING AGENT (ETHENE GAS).

One can clearly see that List 2 has much more chemicals than List 1 and may raise concern with regard to such chemical composition. Interestingly however, the list of ingredients on the left side is that of the Pfizer-BioNTech COVID-19 Vaccine, while the one on the right side is that of an all-natural banana! (16) (17)

Therefore, the widely spread notion that there is a difference between naturally occurring chemicals and chemicals that are synthesized in the lab is utterly false and actually causes an inconvenience in communicating scientific output to the general population. Essentially, everything around us is made of chemicals; the air we breathe, the food we eat, the water we drink, even our own bodies are made of chemicals!

Most importantly, the above list of the Pfizer-BioNTech COVID-19 Vaccine clearly mentions all the ingredients of the vaccine in full disclosure which are all FDA approved as stated by the FDA website.

“Unclear long-term effects of the vaccine”

The questions concerning the long-term side effects of the COVID-19 vaccines are definitely valid. However, according to experts, there’s no reason to worry about such effects. Dr. Paul Offit, a vaccine specialist at the FDA advisory board, stated that any rare long-term severe side effects of the vaccine would have been most likely seen in the Pfizer study on tens of thousands of the vaccinated people up to 6 weeks post vaccination (18).

This is consistent with what the infectious diseases expert Dr. Aileen Marty had to say about potential long-term side effects of the vaccine. Dr. Marty mentioned that any significant long-term side effect would be observed within the first two months after the 7-days post second-dose vaccination and that it would be quite rare to detect any significant effects after these two months (19).

Thus, even though it remains imperative to monitor the vaccinated people beyond the 2-month post-vaccination mark, experts agree that any concerns about long-term side effects of the vaccines should be put to rest for the time being.

"Why not similar vaccines for cancer and HIV?"

A major contributor to the skepticism surrounding the Covid-19 vaccine is the alleged absence of vaccines for cancer and human immunodeficiency virus (HIV). Although entirely valid, this fear seems to be fueled by the lack of understanding and spread of misinformation concerning these diseases. That being said, vaccines for these conditions do exist, so let us first delve into the nature of cancer and HIV to better understand the challenges that complicate the vaccine development process of these diseases.

The way vaccines work largely depends on the body's ability to detect pathogenic domains called antigens (20). Vaccines mimic this natural response by introducing weakened pathogens or inactive pathogenic subparts that are antigenic (20). Given this information, tumor cells in cancer exist in highly heterogeneous populations in which these cells not only produce antigens that are different from the host, but also different from each other (21). More importantly, cancer is a

diverse set of conditions that consists of hundreds of various subtypes that present different sets of antigenic combinations that are impossible to determine until the tumor has already emerged (21). This means that not only is it impractical to target cancer cells with a single vaccine, but it is also impossible to use vaccines prophylactically for prevention purposes (21). In fact, the two most widely used cancer vaccines do not prevent cancer itself, but rather induce an immune response against human papillomavirus or hepatitis B virus, which are causative agents of cervical cancer and liver cancer respectively (21). Nonetheless, most cancers are not as obviously linked to known viruses, rendering the potential for similar approaches minimal at best.

As for HIV, the question that asks itself is not "why is there no vaccine?" but rather "why have the vaccine candidates thus far failed?" HIV is a virus that functions by attacking its hosts immune cells, making the host much more vulnerable to acquiring disease (22). Untreated, HIV can develop into acquired immunodeficiency syndrome (AIDS) (22). Therefore, and unlike other diseases, upon viral integration of HIV into our chromosomes, our bodies cannot naturally eradicate the infection, nor can vaccines depend on the natural immune response that will have become compromised following exposure (22). Nonetheless, several vaccine candidates have been investigated but most have unfortunately failed or exhibited modest efficacy due to this mechanism of action of HIV that is mainly inducing immunosuppression (23). This generates a paradigm shift in the rational design of HIV vaccines through which conventional targeting strategies become obsolete. That being said, novel vaccine trials have been initiated that revolve around inducing both T-cell mediated immunity as well as antibodies (24). The data from these trials will hence be publicized in the years to come (24).

It is important to realize that vaccine development is not a standard process that can by default provide therapeutics for any disease but rather a nuanced mechanism that is dictated by the nature of the disease itself. As we have seen, although the presence of cancer and HIV vaccines might not be common knowledge, these medicines are in fact, available and heavily investigated. Thankfully, due to the structural and functional aspects of Covid-19, the formulation of the vaccine was not as convoluted as that of the diseases mentioned above. That being said, it is still of utmost importance to conduct proper research before jumping to conclusions concerning therapeutics.

"Why not just let herd immunity take care of it?"

Herd immunity is a state where a large enough number of susceptible organisms become immune to a certain pathogen. The idea behind it is that the number is high enough to prevent the transmission of said pathogen because an infected individual would then be unlikely to be in contact with a susceptible (non-immune) individual (25).

However, this is not to be taken lightly and at face value. There is more nuance to herd immunity than meets the eye, for there are multiple factors involved like how the pathogen is transmitted, what the infection dynamics of the pathogen are, as well as how immunity can be acquired (26).

How does this work in the context of the vaccines we are discussing? The vaccination program aims to vaccinate the majority of the population, leaving the minority unvaccinated. The immediate reaction of part of the general public has been to assign themselves as the unvaccinated minority, depending on others to vaccinate themselves to confer herd immunity. Unfortunately,

we don't get to decide who doesn't get vaccinated based on preference. The decision is based on need. There are people who cannot get immunized through vaccination, like immunocompromised individuals and young children (27).

When you decide not to get vaccinated, you will be contributing to causing two harmful things to the population besides putting yourself at risk. First, you are allowing yourself to be a more optimal host for the virus, thus disabling efforts to minimize its transmission. Second, you are giving it more chances to mutate and produce new variants not only inside of you but also in the bodies of everyone who is infected because of you directly and indirectly. The latter is probably the more important point that the general public is missing. We are currently at a race with evolution. We don't know when a new variant that is resistant to the vaccine could emerge, and so must put a stop to viral transmission before it's too late. Data published confirms that the new vaccine is protective against the latest variant. Let us not miss our golden opportunity to stop this pandemic.

Herd immunity is not meant to give us the luxury of choosing whether to get vaccinated or not. It is the only way we can protect vulnerable individuals whose immunity cannot be boosted by the vaccine. To assure their protection, everyone who is of the majority should get vaccinated. It is our duty and responsibility to take the vaccine.

"Will the vaccine be effective against the new strains?"

An emerging concern following the appearance of new variants of Covid-19 is whether or not the vaccine will be effective against them. Data suggests that the BNT162b2 vaccine confers

95% protection against the canonical variant of Covid-19, but new variants have since been reported in the United Kingdom and South Africa (28). These variants contain mutations in their S glycoproteins which are essential targets for the antibodies that neutralize them (28). These mutations thus increase the strain's ability to bind to the angiotensin converting enzyme 2 receptor as well as expand its ability to infect mice (28). Nevertheless, clinical strains were genetically modified to mimic these mutations and the data provided suggests that no reduction in the neutralization activity against the virus was observed following immunization with the vaccine (28). Although not all the possible mutations have been tested in a clinical setting, the rapid response to the new strains is testimony to the thoroughness of the research being conducted. At worst, the vaccine will have to be modified to target these variants in a manner that is similar to that presented by the flu and its seasonal shots (29).

In short, vaccination has proven to be a promising method of protection against the virus and its possible variants and there is no reason to believe that the efficacy of the vaccine will be compromised.

Conclusion

As we have seen, the fears surrounding the use of a Covid-19 vaccine are numerous, widespread, and unfortunately deeply rooted in false notions the general public has developed concerning the virus. In a world heavily impacted by politics, misinformation can and has been weaponized to spread discord among the people such that we become avatars for political gain that benefits no one. It is our duty as the scientific community to dissect these fears and debunk the detrimental claims that threaten the health and lives of millions. It is more so our duty as humans

to conduct proper research and educate others where needed to halt the spread of misinformation. The vaccine will contain the spread of Covid-19, but not if we refuse to take it. That being said, wash your hands, wear your masks, maintain social distancing, and most importantly, educate one other.

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