Review Article

A Review on Variants of Coronavirus and the Effect of Different Vaccines on it

Quratulain Maqsood[1*], Esha ameen[2], Muhammada Mahnoor[3], Aleena Sumrin[1], Muhammad Waseem[3],

[1]Centre for Applied Molecular Biology, University of the Punjab, Pakistan; [2]Department of molecular biology and molecular genetics, University of the Punjab, Pakistan; [3]Akhtar Saeed Medical & Dental College Lahore Pakistan

Corresponding author: Maqsood Q, Department of Applied Molecular Biology, University of the Punjab, Lahore, Pakistan, E-mail: qmabc160403473@gmail.com

Abstract

Many people are dying in the whole world due to coronavirus every day. The novel coronavirus is the cause of mass death in many countries. It is an RNA virus. This disease started in Wuhan, China on November 17, 2019. It was a wild type of coronavirus. Studies on RNA viruses have shown that they have a certain potential for modification. Modifications to viruses can cause the complete vanishing of the virus or create a new version of it. Similarly, with time, the wild type of this virus is also showing mutations and new variants of this virus are emerging. There are four waves of this virus that were observed from 2019 to 2021. These four waves are because of the four strains of the Coronavirus that include Alpha, Beta, Gamma, and Delta. Each strain is observed in different geographical regions but travels to other countries as well. Every new variant is stronger than the previous one. The new variants are more contagious, infectious, and deadly. Since the first variant has been observed, different companies and institutes all around the world have started working on vaccine production. Different companies came up with the vaccines, such as Pfizer, Moderna, and J & J. These vaccines went through a long process of clinical trials which consisted of three phases. All these vaccines are distributed worldwide. These vaccines have shown different effects on the different variants. Age is also a factor affecting the efficacy of a vaccine. This is the fact that these vaccines were made at the time of the Alpha variant. Therefore, it is reported that they have shown less effectiveness against other variants.

Keywords: Coronavirus; Variants; Vaccine; Strains; Modification; Viral RNA

Introduction

Novel Coronavirus is a group of viruses from the family Coronaviridae (RNA viruses). SARS and MERS that emerged before the coronavirus also belong to the same family.

It caused a pandemic situation in the whole world. [1] COVID-19 is a zoonotic infection caused by CoV-2. The major problem is that this disease can spread by direct contact and respiratory droplets.

It was present in animals such as bats and camels and switched hosts to humans after certain modifications. It tends to change itself after a certain time. [2]

Variants of Coronavirus have evolved by modifications to their genome and chemical structure.

These variations are very sudden, and it makes this virus more deadly and contagious. The variants are being studied by many scientists to find their lineage with the original virus. [3] These studies have shown similarities and differences between the variants of the Coronavirus. Most of the variants differ by the modification of their spike proteins (spike-like surface proteins). After all this research, these variants are given scientific names according to modifications by WHO (World Health Organization), such as B.1.1.7 (alpha), B.1.351 (beta), P1 (gamma), and B. 1.167.2 (delta). [4]

The world's healthcare authorities have started doing their best to prevent people from getting this disease. Therefore, they started working on the production of the vaccines. Now, many biopharmaceutical companies have made vaccines and launched them around the world, such as Pfizer and AstraZeneca. Many companies are still working on making the vaccine according to the current variant. Studies have shown that, unlike DNA viruses, RNA viruses modify more

How to cite this article: Maqsood Q, et al.. A Review on Variants of Coronavirus and the Effect of Different Vaccines on it. Ann Med Health Sci Res. 2021;11:1-12

quickly. [5] It is because of this reason that it is difficult to control and prevent the transmission of this virus with vaccines. There is a direct relationship between the number of cases and the number of mutations. Whenever the virus enters the human body, it will mutate. If a vaccine is made against a certain variant, it is more likely not to work against the other variant. [6] Therefore, the vaccines are always under examination to check their efficacy against the new variants.

How are mutants formed?

As mentioned earlier, COVID-19 is an RNA virus; it is its property to change/mutate with time. The question that arises here is what makes this virus mutate?

The answer to this question is very simple. The viruses have glycoprotein or commonly called spike protein on their surface. [7] These proteins assist the virus to attach to the cells of the host by binding to the receptors present on the cell surface. After binding, it releases its RNA into the cell. Now, the viral RNA uses the host machinery to make its copies. But sometimes errors happen during the copying process. [8] If the RNA continues to copy with this error, eventually, it leads to a mutation in the virus genome. This phenomenon does not completely change the genome but modifies a certain part of it. Therefore, the virus remains the same, but the effect of its infection might change. For example, symptoms during the infection change. That is why they are called 'variants of the same virus. [9] It sounds the same as the strains of the same bacteria.

Types of variants

From the start of the pandemic till today, there are different variants seen worldwide, including Alpha, Beta, Gamma, and Delta. The variants are distinguished based on the region of emergence and modification of specific parts. Another property defines the variants. [10] This property is its transmissibility (rate of transmission) because of genetic change.

Figure 1: Alpha, Beta, and delta variant of coronavirus.

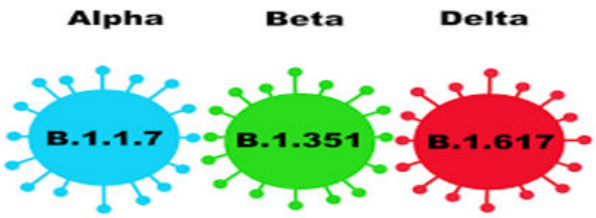


Figure 2: Changes in the electrostatic potential of the spike (electric load at rest) are caused by mutations in the SARS-CoV-2 variant. Positive areas in blue and negative portions in red are shown here. The RBD and N-terminal domain (NTD), which significantly influence the ability of antibody binders to neutralize the virus, have changed in the beta form. [11]

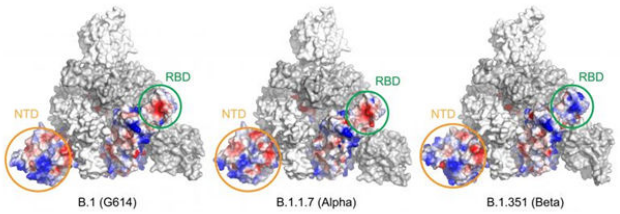
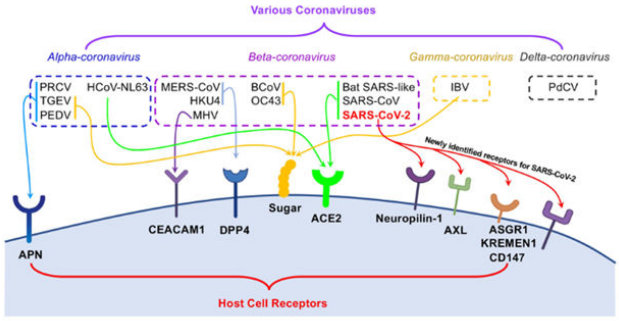


Figure 3: A variety of receptors for viral attachment and input are utilized by various coronaviruses. The four main genera, alpha, beta, gamma, and delta-coronaviruses are in the upper panel on the dashed line. In the bottom panel, the viral entry of a certain coronavirus is mediated by several receptors on the host cell surface. PRCV swine coronavirus, TGEV swine coronavirus, PEDV Porcine Epidemic Coronavirus, MERS-Co V middle east respiratory illness, MHV mouse hepatitis coronavirus, bovine coronavirus BCoV, IBV avian coronavirus infectious bronchitis, PdCV pig delta-coronavirus. The host cell receptors are as follows: APN amino peptidase N, CEACAM1 antigen molecule-based carcino embryonic cell adhesion, DPP4 dipeptide peptidase, ACE 2, ASGPR Asialoglycoprotein receptor. [12]



Alpha variant

This variant is scientifically called B.1.1.7. This variant was first recognized in the United Kingdom. It was identified in September 2020.[13]

This variant can tightly attach to the cell receptor with the help of spike proteins. It makes this variant transmit 70% more quickly than the original virus (wild type). This effect is the result of the mutated N501Y position in spike proteins that help in binding the receptor. [14]

It is due to the higher transmission risk that this variant has already spread to almost 50 countries. After the United Kingdom, this variant was also identified in the United States, France, Belgium, and Denmark. It has shown a greater risk of death. [15]

Beta variant

Its scientific name or classification is B.1. 351. Firstly, it was identified in South Africa. It emerged in May 2020. [16]

This variant has shown mutations in several positions in the spike proteins such as E484K and K417N. It has a similarity

to the Alpha variant as it has a mutation at the N501Y position. [17]

Transmission: After South Africa, this variant was seen in 20 countries, such as Nigeria, the United States, and the United Kingdom. It showed a 50% higher transmission rate than the previously known variant. It was also observed that it spread more quickly in older people. [18]

Gamma variant

It is scientifically called P1. It was first observed in Brazil. It emerged in November 2020 in a woman. She was 29 years old and traveling. [18]

Modification

It has a mutation at position E484K and N501Y in spike proteins, like the Beta variant. It has one more mutated position to make it different, which is K417T. [19]

Transmission

It was reported that this variant mostly targets people who had previously recovered from the Coronavirus (initially infection). This variant was transferred to Japan by travelers in January 2021. Ten other countries were also affected, which included the United Kingdom. [20] It was considered more contagious because it was infecting people that had had Coronavirus before.

Delta variant

Its scientific name is B.1617.2. It was seen in India in October 2020. [21]

Modification

It showed mutations at positions E484Q and L452R on the spike protein. This helps in the strong binding of the spike proteins to the receptor. [22]

Transmission

It has the highest transmission rate/transmissibility of all the previously known variants. It caused the highest number of casualties in India. There was a complete lockdown situation due to this variant. [23] Despite this lockdown, this variant could be transferred to 43 countries, such as Australia, the United Kingdom, Singapore, and the United States. Unlike other variants, it was more common in young people.

Types of Vaccines and their effect on the Variants

There are many vaccines designed to prevent people from getting the different variants. These vaccines include Biotech-Pfizer, Modern, Johnson and Johnson, Oxford-AstraZeneca, and Novavax. These have shown different effects on the different variants.

Biotech-Pfizer

It was the first vaccine to be approved by the FDA (Food and Drug Administration) and EUA (Emergency Use Authorization). It went through a long process of clinical trials. It was found effective against the Coronavirus and launched around the world. It is an mRNA (messenger RNA) vaccine. Its maintenance is not easy. It is kept at very low temperatures in the freezer. [24]

It was initially made for emergency use. It was first used in the United States and then in other countries. It is for children of age 12 or older people. It is also under trial for children under 12. Its two doses are given after a 21-day/3-week interval. It is known as the Comminute vaccine in the European Union. [25]

Working

Many vaccines use attenuated microorganisms, but this vaccine uses mRNA that has the genetic code of the Coronavirus genome. When the mRNA is injected, it gives signals to the cells to make glycoprotein spikes. [26] These proteins help in generating immune responses by infecting the cells of the host. This response is enough to create antibodies. Antibody generation leads to the production of memory cells. These memory cells hold the information about the virus and whenever the body is again infected, these cells generate an immune response quickly. [27]

Effect on variants

BioTech-Pfizer was effective only up to 95% against the Alpha variant and the beta variant. But the recent variant, the Delta variant, is less sensitive to this vaccine. [28] In England, it is reported that this vaccine is only 88% efficient against the Delta variant. It is suggested that the third dose of this vaccine could give a better result against the delta variant. [29]

There are many side effects shown after a few hours of getting vaccinated by this vaccine. These include headaches, pain in the body, fatigue, and swelling at the injection site. But these effects can be resolved in two days with the help of proper medication. Acetaminophen is suggested in this case. [30]

Moderna

This vaccine is also produced for emergency use by the United States. It was authorized a few days after the BioTech-Pfizer vaccine. It is also an mRNA vaccine. The maintenance and efficacy are the same as the Pfizer vaccine. It was used by the United States and the European Union first, and then in other countries as well. [12]

The recommendation says that it was made for people who are 18 years or older. Now it is also being used for those 12 years old and older. It also has two doses which are given after a 28-day interval. [31]

Working

As it is the mRNA vaccine, its working procedure is like the Pfizer one. The stimulation of the spike proteins helps to generate the immune response. [32]

Effect on variants

It has 90%-95% efficacy. In younger people, 94.1% efficiency was seen, but its efficiency decreases as age increases. In people 65 years or older, the efficiency is only 86.4% reported. [33] It was made against the Alpha and Beta variants. The Delta variant emerged after its production, therefore, initially, it was considered less effective than the Delta variant. The reports have shown that its efficacy against the Delta variant is the same as the Pfizer vaccine. [34]

After vaccination, people have shown side effects such as headaches, chills, fatigue, and redness at the site of injection. Some vaccinated people show anaphylaxis. This condition can be resolved by proper medication, epinephrine. [35]

Johnson and Johnson

It was authorized by the FDA in February 2021. Its three clinical trials were done in November 2020. It is not an mRNA vaccine but a vector vaccine or carrier vaccine. It contains the virus vector. Its maintenance is easier than the mRNA vaccines. It can be easily kept in the refrigerator. [36]

It was first studied and tried for two doses, but later results showed better efficiency with one done only. It is known as the Janssen vaccine in the European Union. Its single dose is given to people aged 18 years or older. [37]

Working

As it was a vector vaccine, it has different working than the mRNA vaccine. The weakened adenovirus (that causes the common cold and flu) is used as a coat that carries the genetic code for spike production. [38] This coat/carrier is harmless, but when the genetic code is released into the host cell, it produces mRNA with the help of the host cell's machinery. It generates an immune response in a similar way to the mRNA vaccine. It produces antibodies and memory cells that prevent future infection.

Effect on variants

It has been observed that the Johnson and Johnson vaccine is 72% efficient. In the United States, 72% of its efficacy is reported. It is more effective against the Alpha variant. It is only 82% effective against the Beta variant. Its efficiency decreases very fast in the case of the Delta variant. [39]

It caused many side effects on the recipients. Usually, it causes fever, pain, and redness at the site of the injection, myalgia (pain in the muscles), and headache. [40]

Oxford-AstraZeneca

This vaccine is used in the United Kingdom and other countries. It is unavailable in the United States. It is comparatively less expensive than other vaccines. Its maintenance is also very easy. It is stored in the refrigerator. It was also made for emergency use in the UK. In the European Union, it is known as Vaxzevria. [41]

It is produced for people aged 18 years and older. Its two doses are given at a 12 week/3-month interval.

It is also a carrier/vector vaccine. Its work is the same as the Johnson and Johnson vaccine. Weakened adenovirus is used as the carrier. It carries the genetic code for mRNA production of the coronavirus, which replicates to generate an immune response. Antibodies and memory cells are generated to prevent infection. [42]

Effect on variants

It shows 76% efficiency after two weeks of getting both doses. People of age 65 years or older have shown better results, with 85% efficacy. It is more effective against the Alpha and Beta variants. It is reported that it has 76.4% efficacy against the Alpha variant. Its efficacy decreases in the case of the Beta variant. It has shown only 60% efficiency against the Delta variant. [43]

Its side effects are a little different from the other vaccines. It causes pain in the body, mild fever, itching, and swelling at the site of the injection. In a few cases reported in March 2021, blood clots in the blood vessels of the recipients were seen. These blood clots caused few deaths in extreme conditions. Due to this effect, its usage was stopped for a few months. [44]

Novavax

This vaccine has shown high efficiency in the third phase of its clinical trials. It is different from other vaccines because it is neither an mRNA vaccine nor a vector vaccine. It is a protein adjuvant. It is unavailable in the United States. It will be distributed in other countries soon. [45]

It is affected by a wide range of ages, from 12 to 84. It also uses two doses to get completely vaccinated. The second dose is given at 21 day/3 week intervals.

Working

As the vaccine is a protein adjuvant, it reinforces the response of the immune system. Unlike other vaccines that make the body produce glycoprotein spikes, this one already has those spikes in it. It takes a nanoparticle approach to production, which makes it harmless. [46] It can easily and rapidly generate an immune response because it does not need to produce mRNA first. The first step of its work is the production of antibodies and memory cells. These will prevent the body from future infection. [47]

Effect on variant

Clinical trials have shown 90% effectiveness against the Alpha and Beta variants. It is 91% effective in the case of people aged 65 years or older. It was first made for the Alpha variant only. Its effects on the other variants are still under examination. [48]

It showed many side effects during its clinical trials. It causes myalgia (pain in muscles, especially around the site of injection), headache, swelling, and tenderness at the site of injection. But these effects can be resolved in a few days. [49]

Conclusion

As the coronavirus is a highly contagious virus, the new variants are even more transmissible. If the virus continues to continuously spread throughout the world, it will be difficult to stop its mutation. Studies have shown that this viral spread can be controlled but can not be stopped completely because the RNA virus once entered the population and keeps changing every day. The spread of the virus can be controlled by vaccination. Along with vaccination, it is necessary to take all the precautions suggested by health care officials. If we can control the number of cases, we can control the mutations also. Therefore, we should get vaccinated, wear masks, sanitize our hands, and keep social distance.

Reference

1. Callaway E, Ledford H. How to redesign COVID vaccines so they protect against variants. 2021; Nature Publishing Group.
2. Cocco P. Vaccination against seasonal influenza and socio-economic and environmental factors as determinants of the geographic variation of COVID-19 incidence and mortality in the Italian elderly. Prev Med. 2021; 143:106351.
3. Conti P. The British variant of the new coronavirus-19 (Sars-Cov-2) should not create a vaccine problem. J Biol Regul Homeost Agents. 2021; 35:1-4.
4. Di Maria E. Genetic variants of the human host influencing the coronavirus-associated phenotypes (SARS, MERS and COVID-19): rapid systematic review and field synopsis. Human genomics. 2020; 14:1-19.
5. Escobar LE, Molina-Cruz A, Barillas-Mury C. BCG vaccine protection from severe coronavirus disease 2019 (COVID-19). Proceedings of the National Academy of Sciences. 2020; 117:17720-17726.
6. Forchette L, Sebastian W, T Liu. A comprehensive review of COVID-19 virology, vaccines, variants, and therapeutics. Current Medical Science. 2021; 1-15.

7. Giordano G. Modeling vaccination rollouts, SARS-CoV-2 variants and the requirement for non-pharmaceutical interventions in Italy. Nat Med. 2021;27:993-998.
8. Ita K. Coronavirus disease (COVID-19): Current status and prospects for drug and vaccine development. Archives of medical research, 2020.
9. Joshi A, S. Paul Phylogenetic analysis of the novel coronavirus reveals important variants in Indian strains. BioRxiv, 2020.
10. Kaslow DC. Certainty of success: three critical parameters in coronavirus vaccine development. npj Vaccines. 2020; 5:1-7.
11. Khalaj-Hedayati A. Protective immunity against SARS subunit vaccine candidates based on spike protein: lessons for coronavirus vaccine development. J Immunol Res. 2020.
12. Zhang Q. Molecular mechanism of interaction between SARS-CoV-2 and host cells and interventional therapy. Signal Transduct Target Ther. 2021; 6:1-19.
13. Koyama T. Emergence of drift variants that may affect COVID-19 vaccine development and antibody treatment. Pathogens. 2020; 9:324.
14. Li YD. Coronavirus vaccine development: from SARS and MERS to COVID-19. J Biomed Sci. 2020. 27:1-23.
15. Maxmen A. Why US coronavirus tracking can't keep up with concerning variants. Nature, 2021:336-337.
16. Binnicker MJ. Emergence of a novel coronavirus disease (COVID-19) and the importance of diagnostic testing: why partnership between clinical laboratories, public health agencies, and industry is essential to control the outbreak. Clinical chemistry. 2020; 66:664-666.
17. Facheris P. Complicated coronavirus disease 2019 (COVID-19) in a psoriatic patient treated with ixekizumab. Int J Dermatol. 2020.
18. Chakraborty CM, Bhattacharya, Sharma AR, Present variants of concern and variants of interest of severe acute respiratory syndrome coronavirus 2: Their significant mutations in S-glycoprotein, infectivity, re-infectivity, immune escape and vaccines activity. Reviews in Medical Virology, 2021:2270.
19. Hitchings MD. Effectiveness of CoronaVac among healthcare workers in the setting of high SARS-CoV-2 Gamma variant transmission in Manaus, Brazil: A test-negative case-control study. medRxiv, 2021.
20. Bashir MA, Durrani RS. Novel coronavirus (COVID-19): Its implications for anesthesia. Anaesthesia, Pain & Intensive Care. 2020; 24:1-3.
21. Vaughan A, Delta to dominate world. 2021, Elsevier.
22. Moona AA. Bangladesh reported delta variant of coronavirus among its citizen: Actionable items to tackle the potential massive third wave. IPIP, 2021.
23. Lopez Bernal J. Effectiveness of Covid-19 vaccines against the B. 1.617. 2 (delta) variant. NEJM. 2021.
24. Moore JP. Approaches for optimal use of different COVID-19 vaccines: issues of viral variants and vaccine efficacy. Jama. 2021; 325:1251-1252.
25. Mueller T. Antibodies against severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) in individuals with and without COVID-19 vaccination: A method comparison of two different commercially available serological assays from the same manufacturer. Clinica Chimica Acta. 2021; 518:9-16.
26. Raja AT, Alshamsan A, Al Jedai A. Status of the current COVID-19 vaccine candidates: implications in the Saudi population. Saudi Pharm J. 2020.
27. Sah P. Accelerated vaccine rollout is imperative to mitigate highly transmissible COVID-19 variants. EClinicalMedicine. 2021; 35: 100865.
28. Vaidyanathan G, Coronavirus variants are spreading in India what scientists know so far. Nature, 2021; 593:321-322.
29. Viehweger A. Direct RNA nanopore sequencing of full-length coronavirus genomes provides novel insights into structural variants and enables modification analysis. Genome research, 2019; 29:1545-1554.
30. Wong YC. Natural transmission of bat-like severe acute respiratory syndrome coronavirus 2 without proline-arginine-arginine-alanine variants in coronavirus disease 2019 patients. Clinical Infectious Diseases, 2021; 73:437-444.
31. Zhou, W. and W. Wang, Fast-spreading SARS-CoV-2 variants: challenges to and new design strategies of COVID-19 vaccines. Signal Transduction and Targeted Therapy. 2021; 6:1-6.
32. Mahase E. Covid-19: Moderna vaccine is nearly 95% effective, trial involving high risk and elderly people shows. BMJ: British Medical Journal (Online). 2020; 371.
33. Livingston EH, Necessity of 2 doses of the Pfizer and Moderna COVID-19 vaccines. JAMA, 2021. 325:898-898.
34. Pilishvili T. Interim Estimates of Vaccine Effectiveness of Pfizer-BioNTech and Moderna COVID-19 Vaccines Among Health Care Personnel—33 US Sites, January–March 2021. Morbidity and Mortality Weekly Report, 2021. 70:753.
35. Tenforde MW. Effectiveness of Pfizer-BioNTech and Moderna Vaccines against COVID-19 Among Hospitalized Adults Aged≥ 65 Years United States, January March 2021. MMWR. Morbidity and mortality weekly report. 2021: 70.
36. Livingston EH, Malani PN, Creech CB. The Johnson & Johnson Vaccine for COVID-19. Jama, 2021. 325:1575-1575.
37. Mahase, E., Covid-19: Johnson and Johnson vaccine trial is paused because of unexplained illness in participant. BMJ. 2020. 371:3967.
38. Mac Neil JR. Updated recommendations from the advisory committee on immunization practices for use of the Janssen COVID-19 vaccine after reports of thrombosis with thrombocytopenia syndrome among vaccine recipients United States, April 2021. Morbidity and Mortality Weekly Report 2021; 70:651.

39. Jones, I. and P. Roy, Sputnik V COVID-19 vaccine candidate appears safe and effective. The Lancet. 2021; 397:642-643.
40. Cohen J. Vaccine designers take first shots at COVID-19. 2020, American Association for the Advancement of Science.
41. Knoll MD, Wonodi C. Oxford–AstraZeneca COVID-19 vaccine efficacy. The Lancet, 2021. 397:72-74.
42. Wise J. Covid-19: European countries suspend use of Oxford-AstraZeneca vaccine after reports of blood clots. 2021, BMJ.
43. Mallapaty S, Callaway E. What scientists do and don't know about the Oxford-AstraZeneca COVID vaccine. Nature. 2021; 592:15-17.
44. Ostergaard SD. Thromboembolism and the Oxford–AstraZeneca COVID-19 vaccine: side-effect or coincidence? The Lancet. 2021. 397:1441-1443.
45. Mahase E. Covid-19: Novavax vaccine efficacy is 86% against UK variant and 60% against South African variant. BMJ. 2021.
46. Callaway E, Mallapaty S. NOVAVAX COVID VACCINE PROTECTS PEOPLE AGAINST VARIANTS. Nature. 2021. 590:17.
47. Shinde V. Efficacy of NVX-CoV2373 Covid-19 Vaccine against the B. 1.351 Variant. New England Journal of Medicine, 2021. 384:1899-1909.
48. Mahase E. Covid-19: Where are we on vaccines and variants? 2021. BMJ.
49. ShindeV. Preliminary efficacy of the NVX-CoV2373 Covid-19 vaccine against the B. 1.351 variant. MedRxiv. 2021.