

REVIEW ARTICLE

Comparative Studies about vaccine development for COVID-19

Studi Banding tentang pengembangan vaksin untuk COVID-19

Raghda Alsayed¹, Khalid Zainulabdeen¹, Israa Salman², Nany Hairunisa³, Husnun Amalia⁴, Rahimi M. Yusop⁵, Amamer M. Redwan⁶, Emad Yousif¹✉

¹ Department of Chemistry, College of Science, Al-Nahrain University, Baghdad-Iraq

² College of Science, Al-Nahrain University, Baghdad-Iraq


³ Department of Occupational Medicine, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia

⁴ Department of Ophthalmology, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia

⁵ Department of Chemical Sciences, Faculty of Science and Technology, Universiti Kebangsaan, 43600 UKM Bangi, Malaysia

⁶ Department of Chemistry, Faculty of Science, Bani Waleed University, Bani Waleed, Libya

✉ emad_yousif@hotmail.com

 <https://doi.org/10.56186/jbk.127-132>

ABSTRACT

The human respiratory system can be infected with coronaviruses (CoVs), one of the families of viruses that can lead to symptoms ranging from mild to fatal. Seven genera of CVS have been identified as having human infection to date. The virus can spread as fine, liquid particles from the mouth or nose of an infected person when coughing, sneezing, speaking, or breathing. The diameter of droplet particles ranges from large to small. In this review, we summarize vaccine development for COVID-19. We anticipate this study will be a valuable resource for any researcher interested in creating a COVID-19 vaccine.

Keywords: COVID-19; vaccine development

ABSTRAK

Sistem pernapasan manusia dapat terinfeksi coronavirus (CoVs), salah satu famili virus yang dapat menimbulkan gejala dari ringan hingga berat. Tujuh genera coronavirus (CVS) telah diidentifikasi dapat menimbulkan infeksi pada manusia. Virus dapat menyebar sebagai partikel cairan yang halus dari mulut atau hidung penderita yang terinfeksi saat batuk, bersin, berbicara, atau bernapas. Diameter partikel droplet berkisar dari besar hingga kecil. Dalam artikel ini, kami merangkum pengembangan vaksin untuk COVID-19. Kami mengantisipasi bahwa penelitian ini akan menjadi sumber yang berharga bagi setiap peneliti yang tertarik dalam pembuatan vaksin COVID-19.

Kata Kunci: COVID-19; pengembangan vaksin

INTRODUCTION

In March 2020, the World Health Organization announced that Covid-19 had become a global pandemic, as it stated that the symptoms of most people infected with the virus are from mild to severe and will recover without special care. However, some people get seriously ill and need to see a doctor. COVID-19 can cause severe illness or death in anyone of any age. Severe sickness is more likely to impact older persons and those with underlying health issues, such as cancer, diabetes, cardiovascular disease, or chronic respiratory disease.¹

By October 2020, SARS-CoV-2 will have spread to 235 countries, regions, or territories, infected over 43 million people, and killed around 1.15 million people (a 3% fatality rate). Effective vaccination is urgently required to manage the COVID-19 pandemic, given its rapid spread and high mortality.²

What is a vaccine?

Vaccines often contain weak or inactive parts of a certain organism that trigger an immunological response in the body. This weaker version of the vaccination will not make the recipient sick, but it will stimulate their immune system.³

Some vaccinations call for several doses spaced weeks or months apart. It is occasionally required for the formation of memory cells and the generation of lifelong antibodies. A new vaccination must be created using different paths, as depicted in Figure 1.

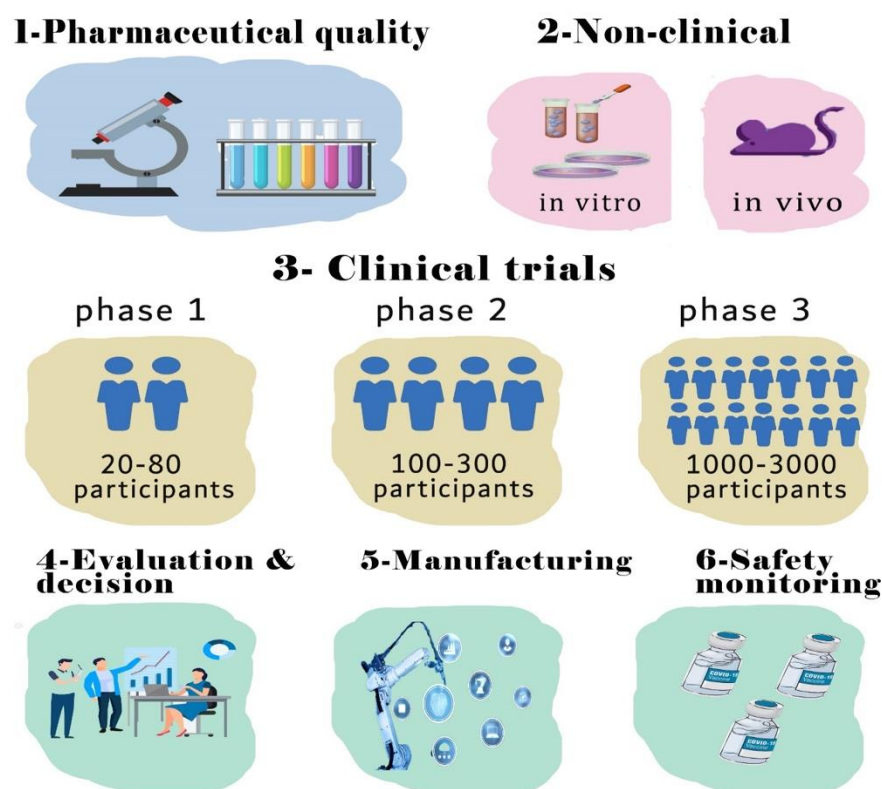


Figure-1 New vaccine generation.

Type of Vaccines

Vaccines are divided into different classes where the vaccines have variable characteristics^{4,5}, as shown in Table -1.

Table 1. Type of Vaccines

Types of vaccines	composition	Mechanism	Example
Live attenuated vaccines	To prevent them from spreading disease, these vaccines include active viruses that have been weakened.	Through a point mutation or the deletion of a critical virus protein, the live attenuated vaccination lessens the pathogenic of the virus while leaving its immunogenicity and capacity for replication unaffected.	Measles, Mumps, Polio (Sabin), Rotavirus, Yellow Fever
Trained immunity-based vaccines	These vaccines transform low-pathogenic, mostly benign viruses into viral vectors that manufacture some of the disease-causing virus's protein components.	Vaccines based on trained immunity can stimulate the adaptive immune system and offer protection against specific pathogens.	Ebola virus
Subunit vaccines	These vaccines don't include any genetic material and instead use antigenic proteins from the disease-causing virus.	Genetic engineering expresses and purifies the pathogen's antigen protein to generate an immunological response.	Pertussis, Influenza, Streptococcus pneumonia
Non-replicating viral vector vaccines	Due to the deletion of the essential viral replication genes from the low pathogenic vector virus, this vaccine cannot reproduce within the body.	It can produce the SARS-CoV-2 full-length S protein.	Hepatitis B virus, Human Papilloma- virus
Inactivated vaccines	To prevent them from spreading disease, these vaccinations contain entire virus particles that have been destroyed or inactivated.	Three inactivation processes are typically used to create inactivated vaccines, which decrease their toxicity and infectivity while keeping their immunogenicity.	Typhoid, Cholera, Hepatitis A virus, Plague, Rabies, Influenza
DNA vaccines	These vaccines employ DNA plasmids that include the SARSCoV-2 gene and other genetic components that will create some of the same antigenic proteins. as the disease-causing virus	DNA vaccines can enter cells similarly to viral infections and use the host protein translation pathway to create target antigens. Immune responses on the cellular and humoral levels might both be triggered at once.	Coronavirus (Gene One Life Science/Inovio Pharmaceuticals/International Vaccine Institute)
mRNA vaccines	These vaccines utilize a messenger RNA (mRNA) fragment that will generate certain antigenic proteins similar to those made by the disease-causing virus.	mRNA vaccines must enter the cytoplasm to cause the expression of the target antigens.	Coronavirus (BioNTech/Fosun Pharma/Pfizer, Moderna

Coronavirus vaccines

Pfizer COVID-19 vaccine

This lipid nanoparticle-based nucleoside-modified RNA vaccine guards against the S protein of the SARS-CoV-2 virus. Viral entry via the ACE2 receptor on type 2 alveolar cells requires the S protein⁶, and this vaccine enables the body to produce an immune response to neutralize the virus. The vaccine mRNA is dissolved in an aqueous solution comprising tromethamine, hydrochloride, sodium acetate, and sugar.⁷ Lipid nanoparticles surround the mRNA, stabilizing it and making it easier to enter cells.⁸ The following lipids are used to create the nanoparticles⁹:

- 1,2-distearoyl-sn-glycerol-3-phosphocholine

- (polyethylene glycol (PEG) 2000-dimyristoyl glycerol (DMG))
- cholesterol

Since the Pfizer COVID-19 vaccine has no live virus, it cannot spread the disease. Vaccines can prevent children from becoming ill from COVID-19. The Pfizer vaccination is administered to children differently than to those 12 years of age and older. Compared to the vaccine for those over 12, the dosage and amount of the children's version are less.⁹

AstraZeneca

AstraZeneca, a British-Swedish pharmaceutical corporation, and the University of Oxford collaborated to create AZD1222, known as ChAdOx1nCoV-19, a non-replicating chimpanzee viral vector vaccine. Including the tissue plasminogen activator (TPA) leader sequence and the full-length codon-optimized coding sequence of the SARS-CoV-2 spike protein.¹⁰ The adenovirus is referred to be replication defective because essential crucial genes required for replication were deleted and replaced by a gene encoding the spike protein. However, many adenoviral genes, including those required for carrier replication, are expressed by HEK 293 cells used in vaccine production.¹¹

The adenovirus penetrates cells after the vaccination and releases its genes, which are then delivered to the cell nucleus by DNA. The cell's machinery subsequently interprets the removed genes into spike proteins by transcribing them into mRNA. Both the Russian Sputnik V COVID-19 vaccine and the Johnson & Johnson COVID-19 vaccine use a technique that utilizes an adenovirus as a vector to deliver spike protein.¹⁰

The first course comprises two doses, separated by 4 to 12 weeks. The World Health Organization (WHO) advises waiting 8 to 12 weeks between doses for maximum effectiveness.¹²

Janssen's vaccine

Human adenovirus type 26 that has the full-length SARS-CoV-2 S protein and is not replicative causes an immunological reaction to the SARS-CoV-2 infection. An antibody directed against the S protein, which lessens the severity and morbidity of the infection, prevents SARS-CoV-2 virus invasion in type 2 alveolar cells of the lungs. Adenoviral vectors benefit from adjuvant properties, scalability, and broad tissue tropism.⁶ On the other hand, since these labs need to acquire biosafety level 2 certification, vaccine production will probably proceed more slowly in an outbreak like the present pandemic.¹³ Additionally, it is possible that a person already has immunity to viral vectors, which would reduce the vaccine's effectiveness. Oxford/AstraZeneca got around this issue thanks to the Chimpanzee adenovirus (ChAdOx1), an alternative to the human Ad vector and immune to humans.¹⁴

Moderna

The Moderna COVID-19 vaccine offers protection against SARS-CoV2 virus infection to avoid COVID-19. The arm's deltoid muscle receives the intramuscular injection of the vaccination. Two doses make up the initial course. The World Health Organization (WHO) recommends a gap of eight weeks between doses. A third, fourth, or fifth dose may be added in some countries.¹⁵

The estimate of a vaccine's effectiveness is typically 50% with a > 30% lower limit of the 95% confidence range. Effectiveness is typically anticipated to decline gradually with time.¹⁶

A couple of weeks after the initial dosage, there is some indication of vaccine effectiveness. The effectiveness estimates were identical regardless of age, gender, race, ethnicity, or presence of medical conditions associated with a high risk of developing severe COVID-19.¹⁷

Side effect

Two doses are needed for mRNA vaccines to provide the best COVID-19 protection:

- The initial shot primes the immune system, which facilitates virus identification.

-A second shot enhances the immune reaction.

These mRNA vaccinations frequently cause side effects, especially after the second dose. After the COVID-19 vaccination, symptoms could appear one to six days later.¹⁸

side effects for mRNA vaccines

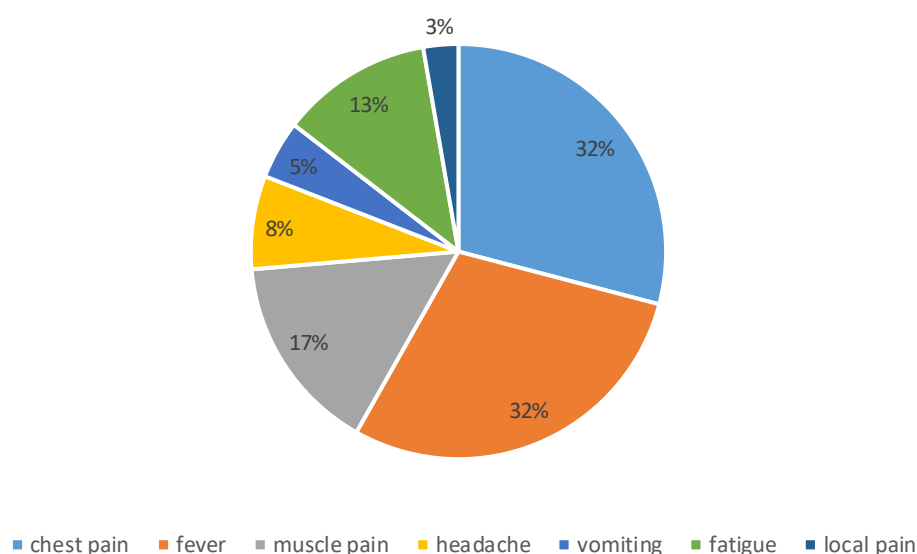


Figure 2. Side effect for mRNA vaccines histogram

REFERENCES

- Gandhi M, Yokoe DS, Havlir DV. Asymptomatic transmission the Achilles' Heel of current strategies to control COVID-19. *N Engl J Med*. 2020;382(22):2158–60.
- Sahin U, Muik A, Derhovanessian E, et al. COVID-19 vaccine BNT162b1 elicits human antibody and TH1 T-cell responses. *Nature*. 2020.
- León TM, Dorabawila V, Nelson L, et al. COVID-19 Cases and Hospitalizations by COVID-19 Vaccination Status and Previous COVID-19 Diagnosis - California and New York, May–November 2021. *MMWR Morb Mortal Wkly Rep*. 2022; 71:125.
- Kanesa-Thanan N, Sun W, Kim-Ahn G, et al. Safety and immunogenicity of attenuated dengue virus vaccines (Aventis Pasteur) in human volunteers. *Vaccine*. 2001 Apr 30;19(23-24):3179-88.
- Fiore AE, Bridges CB, Cox NJ. Seasonal influenza vaccines. *Vaccines for pandemic influenza*. 2009;43-82.
- Embi PJ, Levy ME, Naleway AL, et al. Effectiveness of 2-Dose Vaccination with mRNA COVID-19 Vaccines Against COVID-19-Associated Hospitalizations Among Immunocompromised Adults - Nine States, January–September 2021. *MMWR Morb Mortal Wkly Rep*. 2021; 70:1553.
- Oliver SE. Evidence to Recommendation Framework: Moderna COVID-19 vaccine in children ages 6 months–5 years & Pfizer-BioNTech COVID-19 vaccine in children ages 6 months–4 years.
- Thacker PD. Covid-19: Researcher blows the whistle on data integrity issues in Pfizer's vaccine trial. *BMJ*. 2021;2:375.
- Parums DV. Editorial: first full regulatory approval of a COVID-19 vaccine, the BNT162b2 Pfizer-BioNTech vaccine, and the real-world implications for public health policy. *Med Sci Monit*. 2021; 27:e934625.
- Covid EM. vaccine AstraZeneca: PRAC preliminary view suggests no specific issue with batch used in Austria, 2021.
- Fojnica A, Osmanovic A, Đuzic N, et al. COVID-19 vaccine acceptance and rejection in an adult population in Bosnia and Herzegovina. *Plos one*. 2022 Feb 28;17(2):e0264754.
- Bernal JL, Andrews N, Gower C, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. *bmj*. 2021;13:373.

13. Logunov DY, Dolzhikova IV, Zubkova OV, et al. Safety and immunogenicity of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine in two formulations: two open, non-randomised phase 1/2 studies from Russia. *The Lancet*. 2020;396(10255):887-97.
14. Food and Drug Administration. Fact sheet for healthcare providers administering vaccine (vaccination providers): Emergency Use Authorization (EUA) of the Pfizer-BioNTech COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). Silver Spring, MD: US Department of Health and Human Services. Food and Drug Administration. 2021.
15. Alsayed R, Kadhom M, Yousif E, et al. An Epidemiological Characteristic of the COVID-19 Among Children. *Lett. Appl. NanoBioScience*. 2020;9(3):1156-64.
16. Swissmedic. Swissmedic approves first bivalent COVID-19 booster vaccine in Switzerland. 2022. Available at: https://www.swissmedic.ch/swissmedic/en/home/news/coronavirus-covid-19/bivalenten_covid-19_booster-impfstoff-genehmigt.html
17. Al-mashhadani H, Alsayed R, Hussain Z, et al. "An Overview of Possible Therapeutic Approaches Against Novel Coronavirus Disease 2019 Pandemic" *Al-Nahrain Journal of Science Special Issue: COVID-19*. 2020;special Issue:6-11.
18. Dong Y, Mo X, Hu Y, et al. Epidemiological Characteristics of 2143 Pediatric Patients With 2019 Coronavirus Disease in China. *J Emerg Med*. 2020;58(4):712-3. doi: [10.1016/j.jemermed.2020.04.006](https://doi.org/10.1016/j.jemermed.2020.04.006)



This work is licensed under a Creative Commons Attribution Non-Commercial 4.0 International License
