Iran J Public Health, Vol. 50, No.7, Jul 2021, pp.i-vi

Editorial

A Brief Overview of COVID-19 Vaccines

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(Received 20 May 2021; accepted 29 May 2021)

Since the initiation of the covid-19 pandemic, efforts have been made to provide acquired immunity against covid-19. Prior to Covid-19 vaccines manufacture and authorization, there was established knowledge about the structure and function of coronaviruses that accelerated the capability to produce vaccines (1, 2). After the sharing of genetic sequencing data and the major commitment of the global pharmaceutical industry to address COVID-19, the production of vaccines began. The high efficacy of various COVID-19 vaccines in preventing symptomatic COVID-19 infections was found in large-scale phase III trials (3). During the entire development path of these vaccines, several steps were evaluated including the safety and acceptable toxicity of the vaccine, duration of protective immunity, stability characteristics of each vaccine, heat stability and storage conditions outside the required temperature range, delivery system like injection, oral, and nasal, dosing schedules for COVID-19 vaccines (a single-dose regimen or multiple divided doses), and probable side effects of vaccines (4-12).

So far, billions of vaccine doses had been preordered by various countries and about half of the doses purchased by developed countries with high income (13). Vaccination has been prioritized for those at the highest risk of complications, such as the elderly, health care workers, and people with chronic diseases such as heart diseases, cancer, and diabetes (14). Two doses of different vaccines may work better to protect against COVID-19 and trigger stronger immune responses. For instance, mixing and matching two-dose COVID-19 Pfizer-BioNTech and AstraZeneca vaccines elicit a potent immune response against coronavirus, but target different parts of the virus spike (15). These vaccines have so far been suitable for people aged 18 yr and over, but the recent research by Pfizer on teens aged 12 to 15 yr has shown that the vaccine was effective for this age group and has no significant side effects. The Pfizer-BioNTech COVID-19 vaccine has been approved for this age group, and they can now receive it (16).

Until 19 June, 2021, about 21% of the world's population have been vaccinated with at least one dose, however, only 0.8% of people in low-income countries have received at least one dose of a COVID-19 vaccine (17). Of all the countries, the United States leads with the highest number of injectable doses. After the United States, India, Brazil, the United Kingdom, Germany, France, Italy, Mexico, Canada, and Israel received the most injections, respectively (Fig. 1) (18). Moreover, Canada ranks first in the number of vaccinated people among other countries (Fig. 2) (19). The total number of vaccination doses administered per 100 people in the total population has so far been the highest in Israel, followed by the United Kingdom,

the United States, Canada, Germany, Italy, and France (Fig. 3) (20). Among the total population of countries that have received all doses prescribed by the vaccination protocol, Israel ranks first with more than 50% of its population vaccinated. The United Kingdom, the United States, Germany, Italy, France, and Canada are next in line (Fig. 4) (21). Among all countries, Iran has one of the lowest rates of vaccination with only about 5 million doses of vaccine (Fig. 1) (18). Besides, China has been excluded from the calculations due to the unclear vaccination data.

Different types of vaccines are designed to stimulate your immune system and fight against the novel coronavirus. Based on the best approach and technology available in the production of vaccines, scientists will determine their type. There are different categories of vaccines including messenger RNA (mRNA), live-attenuated, inactivated, subunit, and viral vector vaccines. Each of them has its advantages and disadvantages over the others (Table 1) (18, 19, 21, 22).

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Altogether, it is critical that roughly 70% to 85% of the population must be immune and get vaccinated, but till the end of the pandemic, people still need to keep on wearing masks, ensuring physical distancing, and controlling ventilation in buildings and public spaces. Although some immune responses for example against rhinovirus, the predominant cause of the common cold in humans, triggers an interferon response and blocks SARS-CoV-2 replication (23), vaccines can provide long-term and more effective immunity. Vaccines teach the body to protect against diseases and stimulate the immune system. Immunization against diseases including influenza, polio, pertussis, diphtheria, measles, and tetanus can prevent the death of millions of people each year, therefore, it is a fundamental human right and an essential element of primary health care.

Conflict of interest

The authors declare that there is no conflict of interests

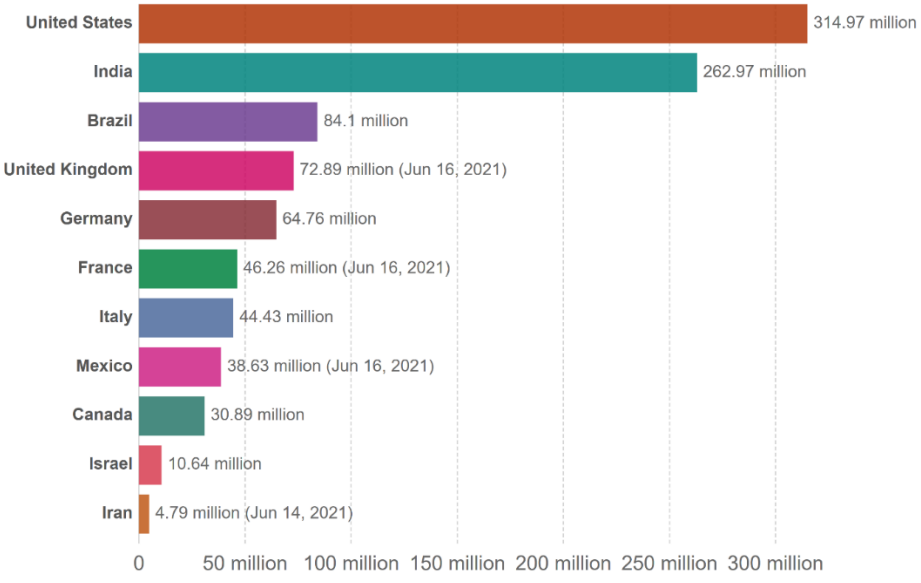

Fig.1: Total number of single dose vaccine administered in the countries with the highest injection rates until June19, 2021. Due to the specific dose regime, it does not represent the total number of people vaccinated (e.g. people receive multiple doses). Iran is included in the chart just for comparison (18)

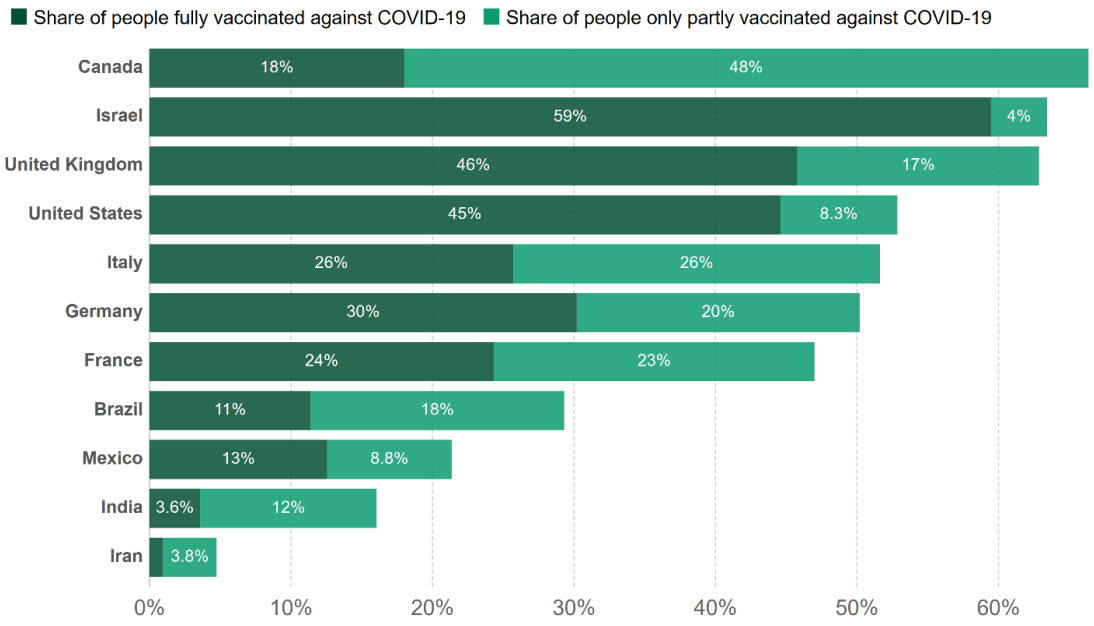

Fig. 2: Share of people vaccinated against COVID-19, which is only available for countries that administered both first and second doses until June19, 2021. The countries with the highest injection rates are listed, and Iran is included in the chart just for comparison (19)

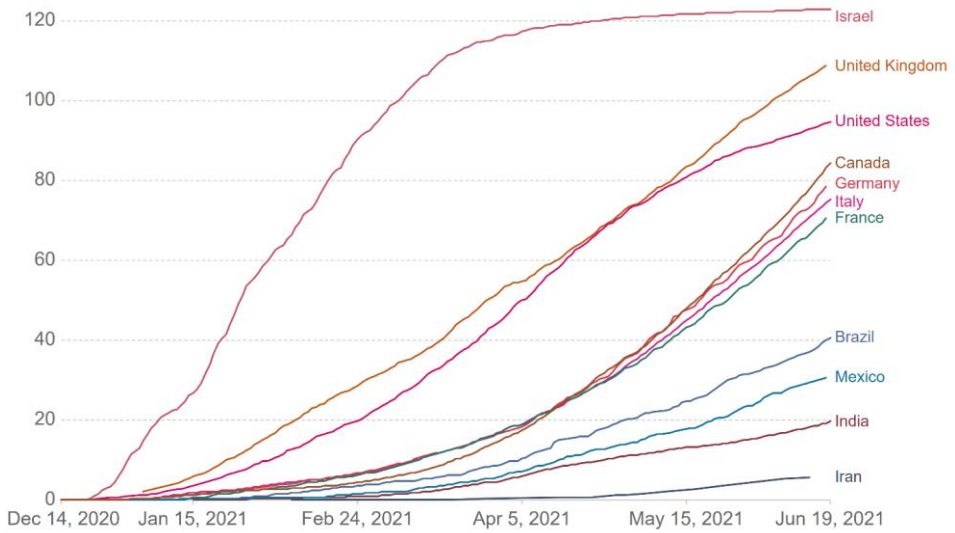

Fig. 3: The total number of administered COVID-19 vaccine per 100 people in the general population until June19, 2021, which is counted as a single dose and does not represent the total number of people vaccinated (e.g. people receive multiple doses). The countries with the highest injection rates are listed, and Iran is included in the chart just for comparison (20)

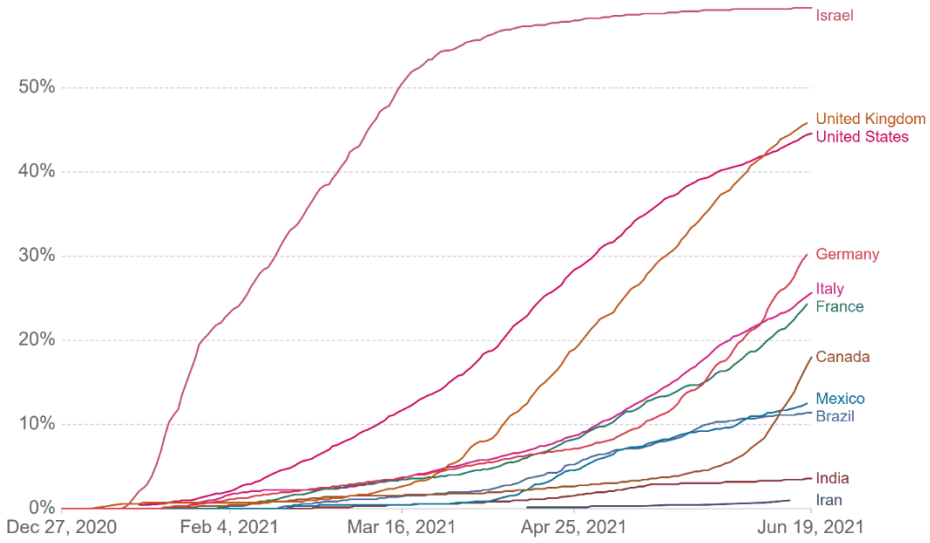

Fig. 4: Share of the population that is fully vaccinated prescribed by the vaccination protocol until June19, 2021. This data is only available for countries that administered both first and second doses. The countries with the highest injection rates are listed, and Iran is included in the chart just for comparison (21)

References

1. Cui J, Li F, Shi ZL (2019). Origin and evolution of pathogenic coronaviruses. *Nat Rev Microbiol,* 17:181-192.
2. Alturki SO, Alturki SO, Connors J, Cusimano G, Kutzler MA, Izmirly AM, Haddad EK (2020). The 2020 Pandemic: Current SARS-CoV-2 Vaccine Development. *Front Immunol,* 11:1880.
3. Krammer F (2020). SARS-CoV-2 vaccines in development. *Nature,* 586:516-527.
4. Martin JE, Louder MK, Holman LA, et al (2008). A SARS DNA vaccine induces neutralizing antibody and cellular immune responses in healthy adults in a Phase I clinical trial. *Vaccine,* 26:6338-43.
5. Wang H, Yang P, Liu K, Guo F, Zhang Y, Zhang G, Jiang C (2008). SARS coronavirus entry into host cells through a novel clathrin- and caveolae-independent endocytic pathway. *Cell Res,* 18:290-301.
6. Wajnberg A, Amanat F, Firpo A, et al (2020). SARS-CoV-2 infection induces robust, neutralizing antibody responses that are stable for at least three months. *Medxriv,* 2020.07.14.20151126.
7. Yu J, Tostanoski LH, Peter L, et al (2020). DNA vaccine protection against SARS-CoV-2 in rhesus macaques. *Science,* 369:806-811.
8. Su F, Patel GB, Hu S, Chen W (2016). Induction of mucosal immunity through systemic immunization: Phantom or reality? *Hum Vaccin Immunother,* 12:1070-9.
9. Wang H, Zhang Y, Huang B, et al (2020). Development of an Inactivated Vaccine Candidate, BBIBP-CorV, with Potent Protection against SARS-CoV-2. *Cell,* 182:713-721.e9.
10. Zhang Y, Zeng G, Pan H, et al (2020). Immunogenicity and Safety of a SARS-CoV-2 Inactivated Vaccine in Healthy Adults Aged 18-59 years: Report of the Randomized, Double-blind, and Placebo-controlled Phase 2 Clinical Trial.2020.07.31.20161216.
11. Jackson LA, Anderson EJ, Rouphael NG, et al (2020). An mRNA Vaccine against SARS-

CoV-2 — Preliminary Report. 383:1920-1931.
12. Meo SA, Bukhari IA, Akram J, Meo AS, Klonoff DC (2021). COVID-19 vaccines: comparison of biological, pharmacological characteristics and adverse effects of Pfizer/BioNTech and Moderna Vaccines. *Eur Rev Med Pharmacol Sci,* 25:1663-1669.
13. Callaway E. The unequal scramble for coronavirus vaccines — by the numbers: Nature 24 August 2020 [updated 27 August 2020. Available from: https://www.nature.com/articles/d41586-020-02450-x
14. Russo AG, Decarli A, Valsecchi MG (2021). Strategy to identify priority groups for COVID-19 vaccination: A population based cohort study. *Vaccine,* 39:2517-2525.
15. Callaway E. Mix-and-match COVID vaccines trigger potent immune response: Nature 593, 491; 19 May 2021 [Available from: https://www.nature.com/articles/d41586-021-01359-3#ref-CR1
16. Pfizer-BioNTech Announce Positive Topline Results of Pivotal COVID-19 Vaccine Study in Adolescents: Pfizer; March 31, 2021 [Available from: https://www.pfizer.com/news/press-release/press-release-detail/pfizer-biontech-announce-positive-topline-results-pivotal
17. Coronavirus (COVID-19) Vaccinations: Our World in Data; 2021 [updated Jun 19, 2021. Available from: https://ourworldindata.org/covid-vaccinations
18. Coronavirus (COVID-19) Vaccinations: COVID-19 vaccine doses administered: Our World in Data; [updated Jun 19, 2021. Available from: https://ourworldindata.org/covid-vaccinations?country=
19. Coronavirus (COVID-19) Vaccinations: Share of people vaccinated against COVID-19: Our World in Data; [updated Jun 19, 2021. Available from: https://ourworldindata.org/covid-vaccinations?country=IRN
20. Coronavirus (COVID-19) Vaccinations: COVID-19 vaccine doses administered per 100 people: Our World in Data; [updated Jun 19, 2021. Available from: https://ourworldindata.org/covid-vaccinations?country=IRN
21. Coronavirus (COVID-19) Vaccinations: Share of the population fully vaccinated against COVID-19: Our World in Data. [updated Jun 19, 2021. Available from: https://ourworldindata.org/covid-vaccinations?country=IRN
22. Iwasaki A, Omer SB (2020). Why and How Vaccines Work. *Cell,* 183:290-295.
23. Pat Bass. What Is an Inactivated Vaccine? : verywellhealth; May 21, 2021 [Available from: https://www.verywellhealth.com/what-is-an-inactivated-vaccine-201081
24. Jiskoot W, Kersten GFA, MastrobattistaE, Slütter B (2019). Vaccines. *Pharmaceutical Biotechnology*, 281–304.
25. Holman DH, Wang D, Woraratanadharm J, Dong JY (2009). Viral Vectors. *Vaccines for Biodefense and Emerging and Neglected Diseases*:77–91.
26. Dee K, Goldfarb DM, Haney J, et al (2021). Human rhinovirus infection blocks SARS-CoV-2 replication within the respiratory epithelium: implications for COVID-19 epidemiology. *J Infect Dis,* jiab147.

Table 1: Understanding various types of vaccines, advantages and disadvantages (22-25)

Type of vaccines	How it works	Advantages	Disadvantages	Existing examples	Group testing this approach for COVID-19
DNA and RNA	This type of vaccine stimulates the immune system against infectious diseases by using DNA or RNA molecules. They teach our cells how to make a protein or a piece of a protein.	• Easy and quick to design • Readily available because of genetic code • Superior production speed • Cost-effective • Enhance both humoral and cellular immune responses • Long-term immunogenicity persistence • Thermal stability of DNA vaccines • Specific immune response only on the antigen of interest ❖ DNA vaccination has become an effective strategy for therapeutic vaccination against cancer	• Ultra-cold storage before distribution • Never been done before • May induce immunologic tolerance by antigens expressed inside the host body • Better performance of RNA-based vaccines than DNA-based vaccines • Limited to protein immunogens • Induction of antibody production against DNA	None	• Moderna (RNA) • Inovio (DNA) • Pfizer (RNA)
Live attenuated	Attenuated or Live virus vaccines use the weakened form of the virus or living bacteria.	• Does not cause serious disease in people with healthy immune systems • Good stimulants for the immune system because of the resemblance to a natural infection • Strong and long-lasting immune response • Need just 1 or 2 doses and/or booster shots	• May not be safe for those with compromised immune system. • Not suitable for everyone to receive, e.g. children or those undergoing chemotherapy • Require special shipping and storage • Small chance of reverting to its original state and causing illness	• Measles • Mumps • Rubella • Chickenpox	• Codagenix • Indian immunologicals Ltd.
Inactivated	An inactivated vaccine or whole virus vaccines use the entire virus particle. The virus is killed or fully destroyed using heat or chemicals.	• Easily stored and shipped • No chance of causing disease in the dead virus	• Less robust response • Need to use large amounts of antigen to elicit an adequate antibody response • Often need multiple doses and/or booster shots • Short durability • Weaker cell-mediated and mucosal immune responses • Increased cost per dose	• Hepatitis A • Influenza • Japanese encephalitis • Polio • Rabies • Typhoid	• Sinovac • Sinopharm • Barakat • Bharat
Subunit	This vaccine uses one or more antigens or a piece of a bacterium or virus surface without introducing pathogen particles to stimulate your immune system and focus on a single target. The involved antigens can be different molecules, such as peptides, proteins, or polysaccharides.	• Used on almost everyone who needs them • Suitable for people with compromised immune systems • Cannot cause infection or disease. • Less chances of side-effects because of the purified antigenic component. • Stronger-response than inactivated vaccines, because of strong antigenic (immune-stimulating) effect of the fragment	• Less immunogenic than live attenuated vaccines. • Require adjuvants to boost long-term immunogenicity • Often need multiple doses or "booster" doses to provide long-term immunity • Difficult isolation of specific antigens to invoke the necessary immune response	• Pertussis • Hepatitis C • Human papillomavirus (HPV)	• Novavax • AdaptVac
Viral Vector	This approach uses a harmless viral vector to carry genetic material coding into human cells to build immune responses.	• High-efficiency gene transduction • Highly specific transfer of genes to target cells • Induction of both potent humoral and cellular immune responses • Reduced administration dose • High efficacy and improved safety • Large scale production • Targets ranging from certain types of cancer to a vast number of infectious diseases • Stronger immune responses than Inactivated or subunit vaccines • Well tolerated in human	• Risk of an immune response to a viral vector that could reduce the effectiveness of the vaccine • Importance of picking a viral vector that is truly safe • Risk of integration into the host genome, which can cause other diseases • Increased genetic instability and decreased virus yield in production by transgene size	• Ebola • Veterinary medicine	• University of Oxford & Astra-Zeneca • CanSino Biologics • Johnson & Johnson • Sputnik V