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Review article

SARS Cov-2 vaccines and vaccination strategies

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ABSTRACT

A rapid change has been undergone in the current pandemic and many countries are being exposed to the third wave of COVID-19. The tireless work for the discovery of vaccine had begun by the time the disease occupied a major part of the globe. This is mainly due to the efficacy of vaccines in preventing diseases and it is one of the cost effective strategies adopted for the prevention of many diseases. Currently a lot of countries have come forth with suitable vaccines to tackle the SARS CoV-2 to some extent. This paper incorporates details about vaccination and the common vaccines in use against COVID-19. Based on the evidences available, keen observations and studies carried out on the previously emerged SARS and MERS, the vaccine against SARS CoV-2 was developed, however the primary focus depend on the spike protein which was considered as a target for the development of suitable immunotherapies and thereby played a potential role in the vaccine development process. Vaccination is the most significant strategy to stop the pandemic and the efficacy of SARS-CoV-2 vaccines provides a genuine gauge of hope for future.

Introduction

A vaccine introduces the structure and biological agents of a specific virus to antigen presenting cells (APC) of the host which in turn engulf it and pass parts of it to activate helper T (Th) cells. These activated cells then trigger alternative immune responses like the activation of B cells and cytotoxic (Tc) cells. Whereas the B cells produce antibodies which will stop the virus from infecting cells while the Tc cells recognize and kill cells that are infected with the virus. Understanding the etiology, epidemiology, pathogenesis and immunobiology is of important for the development of vaccines. Researchers around the world use both classical as well as next generation platforms. The classical platforms include whole inactivated virus, live attenuated virus, protein subunit and virus like particles and the next generation platforms are nucleic acids (RNA and DNA), viral vectors (non replicating and replicating), recombinant protein and antigen presenting cells [1].

The urgent need and the hard work for COVID-19 vaccine production

After the outburst of SARS (Severe Acute Respiratory Syndrome) and MERS (Middle East Respiratory Syndrome), world is currently being exposed to another pandemic SARS CoV-2 (Severe

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Acute Respiratory Syndrome Corona-Virus-2). The sickness quickly unfolded across countries and the attempts for the invention of an appropriate immunogen were on its way. Coalition for Epidemic Preparedness Innovations (CEPI), a multilateral and multinational stakeholder's foundation for the development of vaccine against infectious diseases and Biomedical Advanced Research and Development Authority (BARDA) are the main vital funding source of leading vaccine candidate and other COVID-19 promising treatments [2]. Varied analysis and variety of vaccine candidates are under work which incorporates inactivated vaccine, adenoviral vector vaccine, recombinant subunits vaccine etc. The S protein, act as a focal point and a key element in the vaccination developmental affairs. The Cryo-EM structure of SARS COV-2 S Trimer has also accelerated the vaccine development process [3]. Virus surface protein mediate the entry of virus into the cell that successively binds with the ACE2 receptor, therefore the S protein of SARS CoV-2 has been used for developing most of the vaccine candidates [4,5].

Stages of vaccine development

Stages of vaccine development accommodate following steps; exploratory stage, which last for 2-4 years of time deals with basic research in the laboratory regarding the conceptual idea and development of an antigen which help to treat the disease. Preclinical stage; which carries out the development, uses a platform of tissue culture or cell culture systems and animal testing to assess the safety of the candidate vaccine and its immunogenicity. Animal studies carried out by employing and utilizing animals like mice, rabbits, guinea pigs, monkeys etc. aid and help to find out the immune responses as well as the side effects related to the candidate vaccine introduced for the administration and there by evading the bursting out diseases to some extent. This stage usually takes a time range of 1-2 years. Clinical stages; consist of at least 3 stages and the fourth post marketing safety assessment stage is also mandatory [6].

Vaccines in use and vaccination strategy

With the development of pharmaceuticals, vaccine development progresses through preclinical evaluation with three distinct clinical stages such as phase 1, phase II and phase III trials. The common vaccines developed so far are given in **table (1)**.

Table 1. Common vaccines against SARS-CoV-2.

Vaccines	Type	Manufacturer	Emergency use approval	Administration
COVAXIN (BBV15)	Inactivated	Bharat Biotech	January 2, 2021	Two dose vaccination regimen administered 28 days apart
SPUTNIK V	Non replicating viral vector	Gamaleya National Center of Epid emiology and Microbiology, Russia	August 11, 2020	Two vaccine shots by maintaining a time gap of at least 21 days
BNT162b2	RNA	BioNTech and Pfizer	December 11, 2020	A two dose regimen of 30µg administered 21 days apart
mRNA 1273	RNA	Moderna TX Inc	On 30 April, 2021	Two doses (100µg, 0.5ml each) administered 28 days apart.
CORONAVAC	Inactivated	Sinovac life sciences (Beijing, china)	01 June, 2021	Tow doses (0.5ml)with an interval of 2-4 weeks
ChadOX1nCoV-19 (AZD1222)	Non replicating viral vector	Oxford university	15 February, 2021	Two doses (0.5ml), with an interval of 4 to 12 weeks, according to manufactures 's product lable.
JANSSEN	Non replicating viral vector	Johnson and Johnson	On February 27,2021	Single dose (0.5mL)

COVAXIN

A complete infective SARS COV-2 viral particle, consisting of RNA surrounded by a protein shell, but a modified one so that it cannot replicate [7,8].

Mechanism of action: The vaccine development was carried out using a whole virion inactivated vero cell derived platform technology. The Inactivated vaccines are incapable of undergoing replication or duplication which thereby makes its reversal improbable and are unlikely to cause any pathological effects in those organisms, got administered with this particular vaccine. The vaccine hold dead virus, that are incapable and impotent of causing infection in vaccinated individuals, but are capable of instructing the body's immune system to produce a defensive reaction against an encountered infection. COVAXIN is included along with immune-potentiators, also known as vaccine adjuvants, which are added to the vaccine to increase and boost its immunogenicity. This inactivated virus vaccine, developed in viro cells is combined with alhydroxyquim-II (Algel-IMDG), chemosorbed imidazoquinoline onto aluminum hydroxide gel, as an adjuvant to boost immune response and longer lasting immunity. This particular technology is being used under a licensing agreement with the Kansas based virovax. The use of imidazoqunoline class of adjuvants (TLR 7/8 agonists), shifts the T-cell response towards Th1, a T-helper 1 phenotype (which is considered safer than the Th2 responses produced in opposition to the SARS CoV-2) which thereby turn down the occurrence of immune-pathologically mediated enhanced diseases [9].

Clinical Trials – Efficacy: Results of two dose regimen study administered to Rhesus macaques demonstrated an increase in SARS COV-2 specific IgG and neutralizing antibodies as well as diminished the viral replication in the nasal cavity, throat and lungs. According to the trial principle investigator, initial results from the first fifty participants who received the vaccine seem to be promising. In addition according to Bharat Biotech, the first two phases of the trial did not demonstrate any major adverse events [10].

The vaccine candidate has been found to induce a potent humoral immune response and protects Syrian hamsters from SARS CoV-2 Pneumonia; early viral clearance from the lower respiratory tract in vaccinated hamsters, moreover the inactivated SARS CoV-2 vaccine candidates BBV152A, BBV152B, BBV152C, induced significant titers of SARS CoV-2 specific IgG and neutralizing antibodies in Syrian hamsters. Further the vaccinated hamsters did not exhibit any histo-pathological changes in its lungs, succeeding the SARS CoV-2 infection. The protection of hamster was evident from the lower respiratory tract, reduced virus load in the upper respiratory tract, absence of lung pathology and robust humoral immune response. Adverse events were not seen in animals immunized with a two dose vaccination regimen [11,12].

Covaxin lack the need of its maintenance at a subzero storage as well as a reconstitution requirement and are a ready to use liquid presentation in multi dose vials, stable at 2-8oC. Percentage of all the side effects combined was only 15% in vaccine recipients. It has proven to neutralize the variants B.1.1.7 (alpha) first isolated in UK, P.1-B.1.1.28 (gamma) and P.2-13.1.1.28 (zeta) first isolated in Brazil, B-1.617 (kappa) First isolated in India, B.1.351 and B.1.617.2 (beta and delta) first isolated in RSA and India. After Phase I and Phase II clinical trials conducted on around 800 subjects suggests that the vaccine is safe and provides adequate immune response and protection. The firm is on its way, constructing protocols to expand and elaborate the testing of its vaccine in children's aged 2-15 years. The safety and immunogenicity of inactivated vaccine candidate BBV152 has been established in various animal species such as mice, rats, rabbits, Syrian hamster and also conducted challenge studies on non-human primates (Rhesus macaques) and hamsters [13].

SPUTNIK V

This is a heterogeneous COVID-19 vaccine consisting of two immunogenic components, a recombinant adenovirus type26 (rAd26) vector and a recombinant adenovirus type5 (rAd5) vector both carrying the gene for SARS CoV-2 Spike glycoprotein (rAd26-S and rAd5-S). The vaccine has been made by combining the adenoviruses with the SARS COV- 2 spike proteins which propel the body to make an immune response [14, 15].

Mechanism of action: Following its administration, the vaccine delivers the SARS CoV-2 gene into the cells in the body. The cells will make use of this particular gene for producing the spike protein. Further, an individual's immune system recognizes this spike protein as a foreign material and produces a natural defense-antibodies and T-cells against this particular protein. If, later on a vaccine administered

person comes into contact with the virus [SARS CoV-2], the immune system will recognize the spike protein on the virus and thereby attack it and provide necessary protection. Antibodies and T cells work together to kill the virus; prevent its entry into the body's cells and thereby destroy the infected cells, thus helping to provide protection against COVID-19 [16].

Clinical trial-Efficacy: Gam-COVID-Vac showed a satisfactory safety profile, a strong humoral as well as cellular immune responses were generated in participants in phase ½ clinical trials. The interim analysis of the phase 3 trial of Gam COVID-Vac showed 91.6% efficacy against COVID-19 [17,18].

Vaccine produces protective neutralizing antibody titers against new strains, including Alpha B.1.1.7, Beta B.1.351, gamma P.1 Delta B.1.617.2 and B.1617.3 and variants B.1.1.141 and B.1.1.317 with mutation in the receptor binding domain (RBD) identified in Moscow [19]. Sputnik v does not cause severe allergies. A storage temperature of +2 to +8oC allows the vaccine to be stored in a regular refrigerator without the need to invest in additional cold chain infrastructure [20].

BNT162b2

The BioNTech focus on two candidates, BNT162b1 and BNT162b2, which are lipid based nucleoside modified mRNA vaccine that encodes trimerized receptor binder (RBD) of the spike glycoprotein SARS CoV-2 [21-23]. One of the lipid nano-particle formulated nucleoside mod RNA vaccine candidate, BNT162b1 encodes the SARS CoV-2 receptor binding domain (RBD), trimerized by the addition of a T4 Fibritin fold on domain to increase its immunogenicity through multivalent display. While BNT162b2 encodes the SARS CoV-2 full length spike modified by 2 proline mutations (P2S) to lock it in the perfusion conformation with a motive to increase its potential to excite and bring about virus neutralizing antibodies. They differ in the nucleotide sequences encoding the vaccine antigens and in the overall size of the RNA constructs, resulting in approximately five times the number of RNA molecules in 30µg of BNT162b2 [24].

Active ingredients for BNT162b2 include nucleoside modified mRNA encoding the viral spike (S) glycoprotein of SARS CoV-2, while the inactive ingredients are 2 [(polyethyleneglycol (PEG))-2000]-N,N-ditetradecylacetamide, Cholesterol,1,2-distearoyl-sn-glycero-3-phosphocholine, (4-hydroxybutyl)azanediyl) bis (hexane-6,1-diyl) bis (2-hexyldecanoate), Monobasic potassium phosphate, Sodium chloride, Dibasic sodium phosphate dehydrate, Potassium chloride, Sucrose.

Mechanism of action: The BNT162b2 encodes the SARS CoV-2 spike protein, the expression of which elicits immune responses against the antigen in recipients. The mRNA encodes the membrane anchored full length SARS COV-2 spike protein which stabilizes the S protein in an antigenitically preferred perfusion conformation. The lipid nanoparticle protects the non-replicating RNA from degradation and allows it to be delivered into host cells after intra muscular injection. Once inside the cells the mRNA is translated into SARS CoV-2 spike protein which is expressed on the surface of these cells. The transient expression of this spike antigen induces neutralizing antibody and cellular immune responses against it, which in turn might confer protection against COVID-19 [25].

Clinical trial-Efficcay: In a healthy adult, two 30µg doses of BNT162b2 elicited high neutralizing titers and robust antigen specific CD4+T cell responses against SARS CoV-2. In phase 2-3 part of an ongoing global phase 1-2-3 randomized, controlled trial involving participants 16 years of age or older, the vaccine elicited a favorable safety profile characterized by transient mild to moderate injection site pain, fatigue and head ache and was 95% effective in preventing COVID-19 from 7 days after dose 2. In a randomized controlled trial (RCT), two doses of BNT162b2 had 95% efficacy against symptomatic laboratory confirmed COVID-19 at least 7 days after the second dose, in people aged 16 years or older with no evidence of existing or previous SARS CoV-2 infection. A phase 3 trial of the same demonstrated 95% efficacy in preventing SARS COV -2 infection, 7 days from the second dose.

Moreover it excited high immune response in adults, which translated to a 95% vaccine efficacy among participants in the phase 2-3 trial of 16 years of age or older [26-28].

mRNA 1273

The mRNA 1273 is a lipid nanoparticle encapsulated mRNA based. vaccine that encodes the perfusion stabilized full length spike protein of the SARS CoV-2 [29]. This vaccine is a white to off white, sterile, preservative free frozen suspension of intramuscular injection; contains a synthetic messenger ribonucleic acid (mRNA) encoding the pre fusion stabilized spike glycoprotein (S) of SARS CoV-2 virus. The vaccine also contains the:lipid

(SM-102, 1, 2-dimyristol-rac-glycero-3-methoxypolyethylene glycol-2000[PEG2000-DMG], cholesterol, and 1,2-distearoyl-sn-glycero-3-phosphocholine [DSPC]), tromethamine, tromethamine hydrochloride, acetic acid, sodium acetate, and sucrose.

Mechanism of action: Following the administration, mRNA within lipid nanoparticles reaches target cells and is taken up by cell specific mechanisms. within the cell cytoplasm mRNA is translated by ribosome into the coded protein which are then expreessed onto the host cell surface. when the s protein is detected by the innate immune system adaptive immunity is triggered to ensure future recognition and a rapid response to later encounters such as SARS CoV-2 infections [30].

Clinical trial-Efficacy : The first phase clinical trial began in the united states conducted by Moderna and the vaccine research center (VRC) of the national institute of allergy and infectious diseases (NAID) [31]. A fair and appreciable amount of anti SARS CoV-2 immune response production was spotted in all participants who got administered with this vaccine. Moreover it was immunogenic inducing robust binding antibody response to both full length S-2P and receptor binding domain in all participants after the first vaccination in a time and dose dependent fashion; to boost a high neutralizing antibody responses were also elicited. Seroconversion was rapid for binding antibodies occurring within 2 weeks after the first vaccination which support the need for a two dose vaccination schedule.

Studies of mRNA-1273 in mice shows that the structurally defined spike antigen induces robust neutralizing activity and that the gene based delivery promotes Th-1 biased responses, including CD8 T cells that protect and provide defense against the viral replication in lung and nose without any evidence of immune-pathology. It is important to note that mRNA-1273 also induces Th-1 biased CD4 T cell responses in humans.

The moderna vaccine has shown to have an efficacy of approximately 94.1% in providing protection against COVID-19 starting 14 days after the first dose [32].

CORONA VAC

The vaccine is created from vero cells that have been inoculated with SARS CoV-2 (CNO2 strain). Ndwandwe.D and Wiysonge C.S. COVID-19 Vaccines. Curropinimmunol. 2021 71:111-116. This vaccine is available in china and some other countries including Brazil, Chile, Indonesia, Mexico and Turkey [33].

Mechanism of action: once inside the body, some of the inactivated viruses are swallowed up by antigen-presenting cell. The APC tears the coronavirus apart and displays some of its fragments on its surface. A helper T cell may detect the fragment. If the fragment fits into one of its surface proteins, the T cell becomes activated and can help recruit other immune cells to respond to the vaccine. B cell, may also encounter the inactivated coronavirus, they have surface proteins in a huge variety of shapes, and a few might have the right shape to latch onto the coronavirus. When a B cell locks on, it can pull part all of the virus inside and present coronavirus fragments on its surface. A helper T cell activated against the coronavirus can latch onto the same fragment. When that happens, the B cell gets activated, too. It proliferates and pours out antibodies that have the same shape as their surface proteins. Once vaccinated with CoronaVac, the immune system can respond to an infection of live coronaviruses. B cells produce antibodies that stick to the invaders. Antibodies that target the spike protein can prevent the virus from entering cells. Other kinds of antibodies may block the virus by other means.

Clinical trial-Efficcay: The phase 1 trial showed seroconversion rates of 88%, 100% and 8% in the 3µg, 6µg and placebo groups on day 28, respectively. The neutralizing antibody Geometric Mean Titer (GMT) were 465.8 (95%CI 288.1-753.1), 1395.9 (95%CI, 955.2-2039.7 and 89.8 (95%CI 76.1-105.9) in the three groups respectively. The phase 2 immunization schedule trial showed receiving vaccination on day 0 and 14 resulted in the most promising outcomes, seroconversion rates were 97%, 100% and 0% in the 3µg, 6µg and placebo groups on day 28, respectively. The neutralizing antibody GMT were 44.1 (95% CI 37.2-52.2), 65.4 (95%CI 56.4-75.9) and 2.0 (95%CI 2.0-2.1) in the three groups, respectively.

One case of serious adverse events related to acute hyper sensitivity with presentation of urticarial, 48h after the first dose, was observed. It was managed with chlorophenamine and dexamethasone and recovered within 3 days. An online search executed on the phase 3 study in Brazil exhibited a 50.4% protective efficacy in preventing symptomatic

infections, 78% protective efficacy in preventing mild cases requiring treatment and a 100% prevention of severe cases. Phase 3 studies in turkey and Indonesia showed a protective efficacy of 83.5% and 65.3% respectively [18]. Coronavac has shown good immunogenicity in mice, rats and non-human primates with vaccine induced neutralizing antibodies to SARS CoV-2, which could neutralize ten representative strains of SARS CoV-2.

Moreover the results indicated that the coronavac provided partial or complete protection in macaques from severe interstitial pneumonia after a SARS CoV-2 challenge, which support progression to clinical trials in humans [34].

In phase 1/11 randomized placebo controlled trials, the vaccine appeared safe immunogenic in healthy individuals aged 18-59 years as in those of 60 years or older. Neutralizing activity against the variant B.1.351 (BETA) was reduced. According to the interim result of phase III trial of 10,000 participants in turkey, without evidence of prior SARS CoV-2 infection, vaccine efficacy starting 14 days after full vaccination was 83.5% (95%CI 65.4-92.1).However, lower efficacy rates have been reported in press releases of trials in different countries. From the deep observation and analysis of the study performed over 10 million individuals in Chile, the estimated effectiveness of vaccine was 70% for preventing COVID-19 while it was86-88% for preventing the hospital admission or death.

ChadOX1nCoV-19 (AZD1222)

The vaccine consist of replication deficient simian adenovirus vector ChadOX1, containing the full length structural surface spike protein of SARS CoV-2 with a tissue plasminogen activator leader sequence [35].

Mechanism of action: This monovalent vaccine composed of a single recombinant replication deficient chimpanzee adenovirus vector encoding the s glycoprotein of sars cov-2. The chAdOx1 viral vector is replication deficient as the E1 gene essential for replication has been deleted. thus the virus can only propagate in cells expressing E1 functions but is unable to replicate within vaccinated animals or humans. following administration the s glycoprotein is expressed locally and stimulates a humoral and cellular immune response.

Clinical trial-Efficcay: A higher vaccine efficacy was observed when the participants first received a low dose followed by a standard dose compared with two standard dose recipients. Even though there was a fall off of 13 serious adverse events, in terms of the safety profile; no part was appraised, related to either study vaccine as assessed by the investigators. Case of hemolyticanemia and also three cases of transverse myelitis were disclosed. The independent neurological committee inspected and surmised that among the reported cases, two of them were unlikely to be related to vaccination while one among them was an idiopathic short segment spinal cord demyelination. Phase 3 trials are being performed in the UK, Brazil and USA to assess the protective efficacy and safety of this vaccine [36].

.Humoral as well as cellular immune responses was generated in rhesus macaques succeeding a sole vaccination carried out with ChAdOX1nCoV-19. Protection against lower respiratory tract infection was observed in vaccinated non-human primates after high dose SARS CoV-2 challenge. It was noted that the intensity of local and systemic reactions was apparently higher on day 1 following the vaccination. Adjusted analysis of the effect of prophylactic paracetamol on adverse reactions of any severity in the first 2 days preceding the vaccination with ChAdOX1nCoV-19 exhibited a substantial reduction in pain, feeling feverish, chills, muscle ache, head ache and malaise [37].

Preliminary results of a phase ½ clinical trial of ChAdOX1nCoV-19 in adults aged 18-55 years has shown that the vaccine is well tolerated and generates robust neutralizing antibody and cellular immune response against the spike glycoprotein [38].

Various thromboembolic events were reported after participants have received ChadOX1nCoV-19 (AZD122) vaccinations. One of the causes for this might be allied to post-vaccination immune mediated thrombocytopenia. In a report including 28 patients after receiving A2D122 with thromboembolic events, all of them were tested positive for antiplatelet factor 4 (PF-4) heparin antibodies, which clinically mimics anti-immune heparin induced thrombocytopenia. This was similarly observed in another study were five participants with thromboembolic events (100%) tested positive with high level of IgG anti-PF4 polyanion complexes, measured by enzyme linked immune sorbent assay (ELISA). The adverse reaction may be related to the adenovirus platelet leukocyte complexes formed after the vaccination which are taken up by the liver by the interaction with membrane associated heparin sulphate proteoglycan (MAHSP). Hither MAHSP function as a receptor for the entry of the virus. Heparin can lead to dose dependent inhibition of this reaction

leading to induction of anti PF4/heparin antibodies subsequently heparin induced thrombocytopenia and thrombophilia was observed in patients after receiving A2D122 vaccination [39].

JANSSEN vaccine

The vaccine uses an existing technology that involves adenovirus, a common cause of respiratory infections [40].

The redesigned and improved DNA in the adenovirus produces a key part of the SARS CoV-2 virus particle to which the body in turn produces an immune response. These adenovirus that delivers the SARS CoV-2 DNA particle are incapable of undergoing multiplication, as a result of which it does not cause any infection; as this system is based on stable DNA molecules, which does not require ultra-cold storage, thereby helping in a facile and more easier distribution [41].

The vaccine contain, Recombinant replication incompetent Ad26 vector, encoding a stabilized variant of the SARS CoV-2 spike protein as active ingredient as well as polysorbate-80, 2-hydroxy propyl β-cyclodextrin, citric acid monohydrate, trisodium citrate dehydrate, sodium chloride, ethanol; as inactive ingredient.

Mechanism of action: This vaccine employs a harmless cold virus (adenovirus 26 CoV2) to deliver a gene that carries the blueprint for the spikye protein found on the surface of the coronavirus. The mechanism of action of the vaccine is similar to that of the AstraZeneca vaccine. An adenovirus vector manipulated in the laboratory carries genetic information for the spike-protein in the viral DNA that can generate a specific mRNA. The DNA portions of this adenovirus that would allow it to replicate were deleted from the vector, and consequently, the vector cannot get replicated in human cells. The vaccine is injected into the individuals, and the vector latches onto human cells, where the DNA carrying the information for the SARS-CoV-2 spike protein is transferred into the nucleus without being incorporated into the host cell DNA. The strand of the viral DNA that would normally tell the cell to make more adenovirus particles, gets translated into mRNA that gets transported out into the cytoplasm, where the cell machinery instead of making adenovirus particles produces spike protein. At this point, the viral spike proteins at the surface of the cells induce production of T-cells (CD4 and CD8), cytotoxic cells, plasma cells, ILs, and B-cells that constitute the three primary immune responses (antibodies, Killer CD8 T-cells and helper CD4T-cells) to block the infection.T-cells are crucial for destroying infected human cells, and the antibodies are effective to protect uninfected cells when free viral particles are circulating out of cells (antibodies can easily latch onto spike proteins on the viral surface) [42].

Clinical trial-Efficacy: Initially the Johnson and Johnson vaccine was shown to produce antibodies against SARS CoV-2 in 90% of people who received it after the first dose. The presence of antibodies was seen greater in individuals who received 2 doses of the vaccine.

Data released by Johnson & Johnson suggest that 1 dose of vaccine was 66% effective in preventing moderate to severe COVID-19 and 100% effective in preventing COVID-19 related hospitalization and death. The J&J/Janssen COVID-19 vaccine was 66.3% effective in clinical trials, at preventing laboratory confirmed COVID-19 infection in people who received the vaccine and had no evidence of being previously infected. People had the most protection of up to 2 weeks after getting vaccinated. In clinical trials the vaccine had high efficacy at preventing hospitalization and death in people who did get sick. Moreover no one who got COVID-19 at least 4 weeks after receiving the J&J/Janssen COVID-19 vaccine had to be hospitalized [43].

Conclusion

Development of vaccine was to some point successful in treating the ongoing pandemic. Many more countries are still working to bring out an effective drug and thereby eradicate this dreaded disease that took the life of many. Vaccination stimulates the immune system and produce specific antibodies thereby helpful in treating numerous infectious diseases. Normally an average time of 10-15 years is taken for the complete development of a vaccine but currently taking into account, the necessity and emergent need for an alternative to minimize and control the ongoing pandemic, an immediate development of suitable and safe vaccine was at high demand for which many laboratories around the world were working on it and were successful to some extent in reducing the global rate of viral spread.

In almost all countries, most of the people are vaccinated with different vaccines and lot of studies are going on to identify the efficacy and resilience of the these vaccines. When most of people in a community are vaccinated, the immunity which develop to some extent minimise the

circulation of these pathogens will lead into a herd immunity. Neither a single vaccine not the herd immunity provides 100% protection, but with herd immunity, the people will have substantial protection. Since an adequate remedy for the complete wiping out of this viral disease is not yet discovered, utmost care is to be taken following the protocols, remaining healthy, fit and clean

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