

An update on the status and development of COVID-19 vaccine over the world so far

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Abstract

The covid -19 pandemic has infected millions of people around the world and affected so many lives. It is proving to be more dangerous as it has no clear sign of declining owing to high prevalence, long incubation period and lack of established treatment. Vaccines are the most promising solutions to mitigate new viral strains. The genome sequence and protein structure of the novel coronavirus (nCov or SARS-COV -2) were made available to allow the development of inactivated or attenuated viral vaccines along with subunit vaccines for treatment and prophylaxis. A successful vaccine platform must enable rapid discovery, scalable manufacturing and global distribution to eradicate pandemics, present and future. This SARS CoV-2 resulted in a global pandemic declaration of Coronavirus Infectious disease on 11 March 2020 by the World Health Organisation (WHO). Here, we review current progress and approaches to covid-19 vaccine development at national, international and individual level.

Keywords: Vaccine, SARS-CoV-2, Clinical trials, Antibodies, Mass Vaccination

1. Introduction

In December 2019, a novel coronavirus (nCoV or SARS- CoV-2) belonging to the betacoronavirus family emerged. All human beta coronavirus are unique from one another; however they do share a certain degree of genetic and structural homology. On June 1 2020, the World Health Organization reported > 6 million confirmed cases and 371 thousand deaths globally.

Of note, history has repeated itself, a similar situation occurred as there was the spread of a disease named – Spanish Flu during 1918. Similar to it, COVID-19 harbours the potential to become a seasonal disease. Here are some rare pictures of that period which throws light on the condition which people faced during that time which is quite similar to the present.



Fig.1 Spanish Flu, 1918

Here is the table depicting situation of covid -19 in India as of 24 July 2021:

Total patients	29,316,897
Patients recovered	28,366,601
Active cases	417,327
Total Deaths	424,114
Recovery rate	97.36%
Death rate	1.34%
Total testing	46,82,16,190

Table 1: Picturing the situation of Covid-19 in India as of 24 July 2021

While the situation in the world as of 24 July 2021:-

Total deaths	4,233,121
Total confirmed cases	198,561,249
Active cases	15,036,557

Table 2: situation of Covid -19

More than 10 years ago, scientists predicted the pandemic potential of the coronavirus. Despite the repeated warnings and discussions, the world was not prepared for this pandemic. A vaccine is crucial, in particular because data indicate asymptomatic transmission of Covid-19. The rapid development, distribution and administration of a vaccine to the global population is the most effective approach to quell this pandemic and the only one that will lead to a complete lifting of restrictions. Challenges include the vaccine design itself, but also its manufacture and global distribution. To make the important, lifesaving vaccines available in resource poor and remote areas of the world and to the developing country is of major concern.

From factories to syringes, each and every corona vaccine will need refrigeration to keep it effective and protected for a long time. However, it is estimated that out of 7.8 Arab populations over the world, nearly 3 Arab people live at places which do not have sufficient facility of cold storage. Therefore, the requirement of gigantic cold chain, possibly for temperatures as low as -80 degree centigrade also adds up as a challenge in distribution of covid vaccine.

Another challenge the world is facing today is the mutation of the virus which has resulted in many waves of pandemic which is proving to be a great obstacle in the success rate of vaccines developed till date.

2. The Vaccine strategies

The genetic sequence of SARS-CoV -2, the coronavirus that causes COVID-19, was published on 11 January 2020, triggering intense global R&D activity to develop a vaccine against the disease. The scale of humanitarian and economic impact of the COVID-19 pandemic is driving evaluation of the next-generation vaccine technology platforms through novel paradigms to accelerate development, and the first COVID-19 vaccine candidate entered human clinical testing with rapidity on 16 March 2020.

When designing a vaccine, principally, one needs to know about the components in vaccine design. They are highlighted below:

2.1 Antigen:

A foreign material that can induce an immune response within the body – derived from the pathogen one aims to immunize against. Based on this, vaccine can be categorised as:

- Live – attenuated vaccine: weakened form of pathogens capable of replication, but not causing illness
- Inactivated vaccine: killed form of pathogens incapable of replication or infections.
- Subunit vaccine: minimal antigenic element of a pathogen.

- **Peptide – based vaccines:** All antigens described above contain peptide epitopes.

2.2 Adjuvant:

A stimulatory agent designed to boost immune response towards a co-delivered antigen.

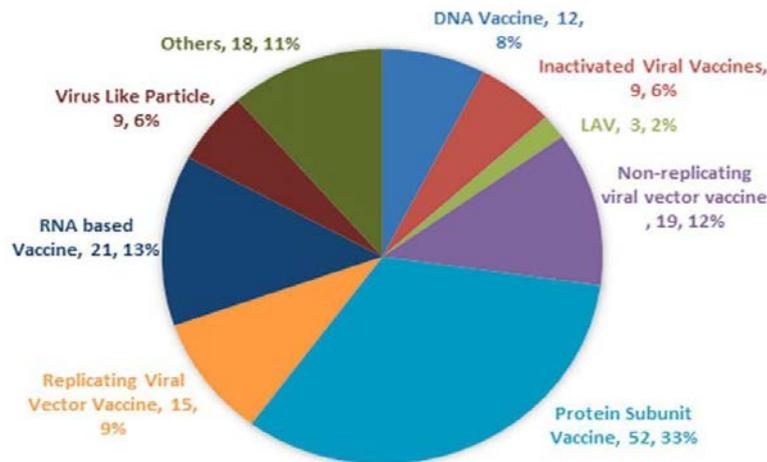
2.3 Device:

A piece of equipment designed to administer vaccine like syringes, implants, Micro needle patch etc. SARS-CoV-2 is an enveloped ssRNA virus with spike – like glycoproteins protruding from its exterior membrane surface forming a ‘corona’. The four major structural proteins of beta coronaviruses are spike (S) proteins, envelope (E) protein, membrane (M) protein, and nucleocapsid (N) protein. The (S) protein is an attractive target for vaccine design as it facilitates viral entry into the host cell during the infection process. This protein is the primary target for various ongoing vaccine development efforts. Candidates aim to induce neutralizing antibodies against the (S) protein, preventing uptake via the human ACE2 receptor. The Coalition for Epidemic Preparedness Innovations (CEPI) is working with global health authorities and vaccine developers to support the development of vaccines against COVID-19.

3. Covid- 19 vaccine R&D landscape

As of July 2020, the global COVID-19 vaccine R&D landscape includes 158 vaccine candidates, undergoing development by academic labs and industries out of which 135 are in preclinical or the exploratory stage of their development. Currently(October 2020) , thirty groups are trying for the preparation of vaccine out of which , Covishield by Serum Institute of India in collaboration with Oxford university , covaxin by bharat biotech , ZyCov-D by Zydus Cadila are presently performing clinical trials and has also reached in phase 2, phase 3 of clinical trials.(Times of India). Moreover, two vaccine frontrunners, Moderna Inc and Pfizer have almost completed last-stage clinical trials.

Covid-19 vaccine landscape with percentage share of different types of vaccine is represented in (Fig. 2.)



(Fig. 2) Pie chart showing the different categories of SARS-CoV- 2 vaccines under research

Here is a list of some rapidly progressing Anticovid -19 vaccines:

Type of vaccine	Developer
<u>Viral vector vaccines</u>	
1) ChAdOx1 / MERS, Influenza	University of oxford/ AstraZeneca
2) Inactivated / SARS	Sinovac

<u>DNA vaccines</u>	
1) Electroporated DNA vaccine	ZydusCadila
<u>RNA vaccines</u>	
1) LNP- Encapsulated mRNA/ Multiple candidates	Moderna / NIAID
2) BNT162/ mRNA	BioNTech / Pfizer
<u>Live attenuated vaccine</u>	
1. LA recombinant measles virus	ZydusCadila

Table 3: anticovid Vaccines

Latest developments in the status of the promising SARS-CoV-2 vaccines :-

Vaccine	Developer
ChAdOx1	University of oxford / AstraZeneca
mRNA-1273	Moderna/ NIAID
PiCoVacc	Sinovac
BBV152(A-C)	Bharat biotech / ICMR/NIV
BNT162	BioNTech FosunPharma Pfizer
ZyCoV-D	Zydus Cadila

Table 4: Promising vaccines

It is very clear that the corona virus disease 2019 pandemic is the most formidable challenge to humanity in a century. It is widely believed that prepandemic normalcy will never return until a safe and effective vaccine strategy becomes available and a global vaccination programme is implemented successfully.

As COVID-19 is new to humankind and the nature of protective immune responses is poorly understood, it is unclear which vaccine strategies will be most successful. Therefore, it is imperative to develop various vaccine platforms and strategies in parallel. Indeed, since the outbreak began, researchers around the world have been racing to develop covid-19 vaccines, with numerous vaccine candidates currently in clinical and last stage trials. Though there remains a lack of clarity as to what may constitute a safe and immunologically effective covid-19 vaccine strategy, yet the basic principle behind every vaccine remains almost alike.

So before discussing about the various vaccines which are being under trials around the world, the general principle behind a developing vaccine needs to be highlighted.

4. General principle behind almost every covid-19 vaccines being developed:

When the corona virus infects a human host, human white blood cells (WBC's) detect proteins present on the coronavirus. These proteins are called antigens and the human immune system shows immune response against them.

A vaccine is incorporated with these important antigens of the virus. This antigen may be killed, greatly weakened, or broken down into small parts before its use in vaccine. Now if this vaccines is administered in human body, then the immune system produces an immune response against these antigens i.e the body will produce antibodies to fight it off. The immune system then keeps a memory of the disease, so if a vaccinated person encounters the disease later, their immune system is ready to fight it off and prevent an infection form developing.

The key of the coronavirus is its spike protein (S protein) which plays an important role in unlocking the human cell and infecting it.

The goal of the covid-19 vaccine is to train the human immune system to develop defense against the S protein of the coronavirus.

According to a research, four types of vaccines for covid-19 are in the development stage.

- Inactive or attenuated coronavirus vaccine use a form of virus that may not cause serious infection, but its antigens may steam up the immune system.
- Protein-based or subunit vaccine contains protein-based antigens that train the immune system to attack the coronavirus.
- Viral vector vaccines use a harmless virus that is made to carry the coronavirus or antigen.
- Genetic vaccines contain DNA or RNA that directs host cells to produce coronavirus proteins, which further act as antigens and steamate the immune system.

One important thing to note about covid vaccines is that most of them which are being developed are of two doses. This implies that they require two injectable doses to be given at intervals of few weeks. This is indeed a challenge in itself for the world.

5. A detailed insight of some of the most promising vaccines

Developer	Vaccine type	Scientific name	Storage Temperature	% of effectiveness
Gamaleya Institute	Viral vector	Sputnik V Gam-Covid-Vac	2-8 degree Celsius	92%
Moderna	Genetic code	mRNA-1273	-20 degree Celsius	94.5 %
Pfizer/ BioNtech	Genetic code	mRNA BNT162b2	-70 degree Celsius	>90%
AstraZeneca/Oxford university	Viral vector	Covishield	2-8 degree Celsius	70.4%
Bharat Biotech	Inactivated Vaccine	Covaxin, BBV152	2-8 degree Celsius	77.8%

Table 5: insight of vaccines

5.1 Sputnik V

The “Sputnik V” is a vaccine developed by the Gamaleya research institute in coordination with the Russian defence ministry. It is based on a proven vaccine against adenovirus – the common cold. It is the world’s first registered vaccine of the world. Hyderabad based Dr.Reddy’s Laboratories is a partner of the Russian organisation Gamaleya Research foundation for the delivery of the vaccine in India.

Antibodies developed after vaccination with Sputnik V protect from all over variants of covid known today. Starting from the UK variant and the so called DELTA variant, first detected in India.

Because Sputnik V has emergency authorisation from medical authorities in Russia, it had also been administered to a section of the population such as doctors and medical workers.

Working:-

The vaccine is administered in two doses and consists of two serotypes of human adenovirus, each carrying an S-antigen of the new coronavirus, which enter human cells and produce an immune response. It is a so-called viral vector vaccine which means that it employs another virus to carry the DNA encoding of the needed immune response into the cells.

“Vectors” are vehicles, which can induce a genetic material from another virus into a cell. The gene from the adenovirus, which causes the infection, is removed while a gene with the code of protein from another virus spike is inserted. This inserted element is safe for the body but still helps the immune system to react and produce antibodies, which protects the body from the infection.

The platforms used for the vaccine was developed by Russian scientists over 20 years and had formed the basis for several vaccines in the past, including those against Ebola. The Gamalaya Research Institute has claimed that this vaccine may increase AstraZeneca/ Oxford’s covishield’s efficiency.

The cost of one dose of Sputnik V is Rs.1,145 .

5.2 mRNA-1273:

It is an mRNA vaccine candidate against the novel coronavirus SARS-CoV-2 encoding for a perfusion stabilised form of spike protein, which was selected by Moderna (American Company) in collaboration with investigators at the NIAID Vaccine Research Centre. It has completed its last stage trial and is expecting about 2 crore doses of the vaccine by the end of the year so it will be available in the U.S by the end of the year. The company said that it provides strong protection. In addition, it reports that the effect of the vaccine is up to 100% in severe cases.

Moderna is applying for the emergency recognition in the US and Europe regarding its vaccine.

The special thing is that no serious security concerns related to the vaccine were revealed.

Working:

This vaccine works differently than traditional vaccines. In this, the vaccine is a small piece of mRNA – an intermediate between DNA and protein to be made by a cell – coding for the “spike protein” of SARS-CoV-2, which targets the surface of human cells. Once the vaccine is injected into a patient’s arm, it will travel inside cells, which will then produce the spike protein. The immune system, recognizing a foreign protein, would attack the spike protein – and learn to attack and destroy the virus just as if the patient were actually infected.

This vaccine requires long term storage at -20 degree Celsius and is stable for 30 days at refrigerator temperatures between 2 and 8 degree Celsius.

The estimated price pitched by Moderna for its vaccine is approx. \$37 a dose which may prove too costly for poor countries.

5.3 BNT162b2 :

It is a vaccine developed by Pfizer (an American Company) in collaboration with BioNtech (Germany). It is composed of nucleoside-modified mRNA encoding a mutated form of spike protein for SARS-CoV-2 and is encapsulated in lipid nanoparticles.

After completion of phase 3 trial, studies shows that it is the only vaccine after Moderna, to be considered to be most safe and effective vaccine. Moreover U.K has granted emergency approval to the vaccine and its mass distribution will be started soon and by this, it becomes the first country to approve the mass distribution of the vaccine. Many European countries have also started administering the vaccine.

Working:

In this type of vaccine, rather than having the viral protein injected, a person receives genetic material – mRNA – that encodes the viral protein. When these genetic instructions are injected into the upper arm, the muscle cell translates them to make the viral protein directly in the body.

This approach mimics what the SARS-CoV-2 does in nature- but the vaccine mRNA codes only for the critical fragment of the viral protein. This gives the immune system a preview of what the real virus looks like without causing disease. This gives the immune system time to design powerful antibodies that can neutralize the real virus if the individual is ever infected.

In contrast to Moderna, who claims its vaccine can be maintained at most home or medical freezer temp. for up to six months for shipping and long term storage , the Pfizer vaccine will need to be optimally stored at -70 degree Celsius and will degrade in around five days at normal refrigeration temp. of slightly above freezing. This is most challenging trait of this vaccine which will be quite a difficult task to overcome. Moreover its shelf life is only about 5 days at refrigerator temperatures adding more difficulty and challenge for most of the countries.

The estimated price for this vaccine is approx. \$20 per dose.

5.4 Covishield:

It is the vaccine developed by Astra Zeneca (U.K) and University of Oxford in collaboration with Serum institute of India. India’s top drug regulator has approved for its emergency approval after the completion of phase 3 trial.

According to the interim analysis, the efficacy of the vaccine was 70.4%. According to researchers, the vaccine was found to be up to 90% effective when isolated. The vaccine was most effective when the first dose was light and the second normal.

According to the database, this vaccine can be easily distributed under the current health care system as it has to be stored at a temp. of 2 to 8 degree Celsius.

COVISHIELD is by far the most advanced vaccine in human testing in India. Based on the phase 2/3 trial results, the SII with the help of the ICMR has pursued the early availability of this product for India. The current average monthly capacity of production of covishield is 11 crores.

Working:

The Oxford’s vaccine is a genetically modified common cold virus that used to infect chimpanzees. It has been altered to stop it causing an infection in people and to carry the blueprints for part of the coronavirus, known as the spike protein. Once these blue prints are inside the body, they start producing the coronavirus’ spike protein, which the immune system recognizes as a threat and tries to squash it by producing antibodies and activate killer

T-cells to destroy infected cells. When the immune system comes into contact with the virus for real, it will know what to do.

The CEO of Serum institute of India said that some 90% of serum institute's doses was esold to the Indian government at around 250 rupees per dose and 10% was given in the private market at the higher price of 1,000 per dose. Moreover the firm also claimed to be able to provide around 10 crore doses of the vaccine in India by December.

Oxford said that more than 10 countries continue to produce this vaccine. Other than the rich countries, the Oxford-AstraZeneca vaccine is raising hopes for low and middle income countries as well. According to a research firm based in London, 40% of this vaccine will be consumed in middle and low income countries. This is because it is much cheaper than other vaccines like Pfizer, Moderna and will be produced in many countries. There is also no need for an ultra-cold temperature for this and also its shelf life is about at least six months which further shows this vaccine to be beneficial.

The maximum rate of covishield is Rs.780 in private hospitals.

5.5 Covaxin:

It has been developed by Bharat Biotech (an Indian biotechnology company) in collaboration with the Indian Council of Medical Research and the National Institute of Virology. It uses an inactivated or non-infectious form of coronavirus. The vaccine has completed the final stages of trial and is available for vaccination drive. These trials were done on 25,800 volunteers in 25 institutions across the country and have been approved by the drug regulatory control of India. After that Indian govt. has ordered for the production of approx. 50 lakh doses of covaxin.

Working:

NIV isolated a strain of the novel coronavirus from an asymptomatic Covid-19 patient and transferred it to BBIL at the beginning of May 2020. The company then began its work of developing an inactivated vaccine that happens to be a vaccine that uses the dead virus. This was done at Bharat Biotech's BSL-3(Bio-Safety Level 3) High containment facility in Hyderabad.

After that the vaccine is injected into a person's body. This virus does not survive, due to which it neither infects nor can flourish in the body. It just serves to the immune system as a dead virus and mounts an antibody response towards the virus.

One interesting fact to note is that the technique on which Moderna's and Pfizer's vaccine is developed, is completely a new and a fresh approach discovered and practiced by the scientists. The world now completely has a new technique based vaccine showing advancement in the field of science and medicine.

6. Vaccine distribution and challenges

While many promising vaccine candidates exist, proving safety and effectiveness is only one of the challenges. When a vaccine candidate proves to be safe and effective, the manufacture and delivery of billions of its doses is a major challenge. Billions of doses of vaccine are needed in the form of multiple glass vials and if their potency is to be maintained, extensive cold chains need to be developed. Experts said that, proper development of cold chains is even much more important than the percentage efficacy of a vaccine. This is because even if the vaccine is more than 90% effective but the country fails to develop appropriate and sufficient cold chains for its storage, the vaccine will automatically reach 0% while with properly developed cold chains, a 60-70% efficacious vaccine would suffice the needs and work well. So maintenance of cold chains is crucial for a vaccine to be successful. India is trying that the storage temperature for all its vaccine may remain in between 2-8 degree Celsius so that it would be easy to maintain the cold chains for this much temp across the country. One thing to note is that, as compared to – 70 degree, it is also practically possible to much greater extent to maintain the cold chain for up to – 20 degree Celsius in India as the country has prior experience to maintain this temperature when they provided mass vaccination of polio disease.

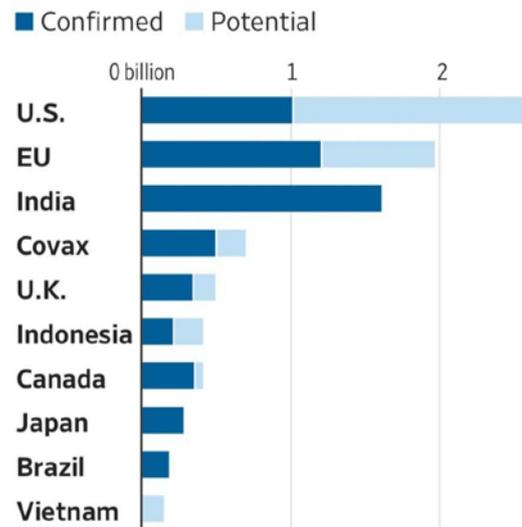
India has a requirement of billions of doses of covid-19 vaccines. Fortunately, India is likely to have shared billion doses of Oxford AstraZeneca, Novovax, Bharat Biotech, Zydus and Sputnik V vaccine. However, India will have to face huge logistics changes in delivering and administering them. Millions of health workers are working to convince Indians to vaccinate and then vaccinate them.

The first challenge is to produce a safe and effective vaccine in an impossible deadline. The major problem lies in ensuring its distribution to such a large population. In relation to this, former health minister of India , Dr.Harshvardhan Singh said that the successful application and administration of vaccine in the country depends on various parameters like the chances of infection in people on administration of vaccine, prevalence of other diseases in various people, mortality rate amongst the covid-19 patients and much more. Taking such possibilities in considerations, he further added that India therefore is looking for the availability of various vaccines according to different age groups as some vaccine could prove to be useful for one age group and the same vaccine may not be so useful for other age group. Keeping this in mind, one vaccine which can be a useful option for India is Moderna's mrna-1273. This is because Moderna reports that the efficacy of its vaccine is not

inconsistent among people of all ages which clarifies the criteria for a vaccine to be chosen for India. Moreover, the special thing is that no serious security concerns related to it were revealed. As Covid-19 vaccines are getting ready, purchase agreements are being tied up too. According to the data that has been revealed so far, India is at number one worldwide in terms of booking Coronavirus vaccine.

According to Duke University’s Launch and scale Speedometer initiative (which studies factors that hinder the delivery of health innovations to lower-income countries), India ranks third in terms of ‘Covid-19Vaccine Advance Market commitments by the Country’ with the United States and the European Union ahead of it.

Committed number of Covid-19 vaccine doses to be purchased by top 10 countries or organizations



Source: Duke University

Fig 3: Purchase number of vaccines

As of November 30, India is at the top in terms of booking of Corona Vaccine’s ‘confirmed dose. Its confirmed dose purchase exceeds 1.5 billion which is more than European Union’s 1.2 billion doses and the United States 1 billion doses. But the US and the EU rank ahead because of their potential dose purchase. The United States has signed up for more than 1.5 billion potential dose purchases. The EU has also signed up for more than 760 million potential dose purchases.

The US also has signed up for more than 2.6 billion doses, which indicates it could inoculate its entire population more than once.

The National Expert Group on Vaccine Administration is working on a time-bound process to inoculate maximum numbers of people once a fully effective vaccine is released.

Researchers at Duke University’s Launch and Scale Speedometer initiative say that the numbers show that more than 8 billion doses of Covid-19 vaccine are currently reserved due to advance market commitments before any clear outcome of the effectiveness of any of the vaccine candidates is yet to be released.

Let’s highlight which country is buying how much confirmed vaccine from:

Oxford-AstraZeneca vaccine: India has booked 500 million doses. At the same time, the European Union has booked 400 million doses. Talking about UK, it has booked 100 million vaccine doses and Canada has ordered 20 million. In the data released by Duke University, only Oxford-AstraZeneca vaccine has been ordered by almost everyone.

Novavax Vaccine: India has ordered 1 billion doses of vaccine to Novavax. However, the US is not buying the vaccine from it. The European Union has ordered 110 million doses, while Canada has ordered 76 million doses and the UK has ordered 60 million doses.

Sputnik-V Vaccine: India has booked 100 million doses of Russian Corona vaccine Sputnik-V. Apart from India, no country has yet booked Russia’s vaccine.

Pfizer-BioNtech Vaccine: The UK has approved the Pfizer-BioNtech vaccine in its country and has also ordered 40 million doses of it. However, America has booked 100 million doses. At the same time, 300 million has been placed by European Union and 20 million by Canada.

Moderna's Vaccine: India has not yet booked its confirmed vaccine. However, the European Union has ordered 160 million doses and Canada 56 million. But it is also a matter of concern here that the US has not even booked it.

Researchers fear that these advanced deals and deals being made to expand the current deals by high income countries as well as middle income countries create a challenge for equal global distribution of coronavirus vaccines.

India is already prioritizing identifying people who would receive the coronavirus vaccine before others. In the first phase, 31 crore people will be vaccinated between March and May. These include healthcare workers, police, priority group members above 50 years of age, and youth from high risk groups and the rest of the population will be vaccinated depending on the epidemic situation and the availability of vaccine.

The person will be monitored for about 30 minutes after giving the vaccine under the guidelines issued by the Centre to the states for covid -19 vaccinations. In addition, only one person will be allowed at the vaccination site at a time. Under this, 100 to 200 people will be vaccinated in each session in a day.

The government has also decided that the initial data from two full-shot results from two dose trials of the Oxford- AstraZeneca vaccine will be considered.

According to Vijayaraghavan, the National Vaccine Committee headed by Dr.VK Paul has prepared a blueprint for who will be the first to be vaccinated. Vijayaraghavan said that one crore health workers in the country, 2 crore of state and central government police, armed forces, home guards, civil defence, 26 crore members of priority group over 50 years of age and below 50 years 1 crore members of the high risk group will be the first to be vaccinated. Earlier, former Union Health Minister Harsh Vardhan has said that the vaccine will start from the first quarter of 2021.

Another initiative taken by the Indian govt. is the development of "COVIN" app. It stands for Covid-19 Vaccine Intelligence Network. This app is developed by the central government and this application has played an extensive role in the vaccine rollout plan. All the vaccine related information and details about its purchase, distribution, circulation, storage and dosing schedule has been uploaded on this app.

According to the guidelines, the Covid Vaccine Intelligence Network System is being used to locate beneficiaries listed for vaccination. At the place where vaccination will take place, only those already registered in priority will be vaccinated.

Apart from India, other countries are also performing mass vaccination.

In Britain, the Prime Minister Boris Johnson said that the military has started to convert Bristol Football Stadium into a vaccination centre. As soon as the vaccine will get approval, they will use this stadium to vaccinate approx. 1 lakh people of the country at a time.

The process of applying the vaccine to high risk patients has already started before the result of Phase-3 trials in China and Russia. For this, China has given emergency approval to four vaccines and Russia two. Moreover Vladimir Putin, the president of Russia has ordered to start the mass vaccination. Canadian drug regulator, Health Canada, has said it will approve Pfizer- Biotech's Covid-19 vaccine around December. Supria Sharma, Senior Medical Advisor at Health Canada said that the vaccine has been at the forefront of the Health Canada review. A final decision of Pfizer's vaccine may also be taken in Canada's neighbouring country in December and it can be approved for emergency use.

7. Individual Efforts to find a solution for the Covid-19 virus

A 14 year old Indian-American girl named Annika has discovered a molecule which can selectively bind to the spike protein of the SARS-CoV-2 virus and thus hinders its functioning. She used various computer programs to find out that how and where the molecule will bind to the SARS-CoV-2 virus.

8. Some key facts

- UK becomes the first country to grant emergency approval of Pfizer/ BioNtech's vaccine. Apart from this, its emergency use has also been approved in the US. The process of giving vaccine to people has been started. Health workers are being given the corona vaccine first in America.
- According to researchers, after administration of the vaccine, side effects can be seen in the person's body. Apart from fever, headache, vomiting, muscle pain, dizziness can also occur.
- In the trials of Pfizer's, Moderna's and Oxford-AstraZeneca's vaccine these side effects were seen in volunteers.
- India's experience in mass vaccination with the Pulse Polio Program and Universal Immunization
- Programs will prove useful in mass vaccination of crores of Indians in an impossible timeframe.
- Russia is the first to start mass vaccination of Sputnik V in the country.
- The American scientists have found a chemical present in normal day to day things which can hinder the effect of covid-19 vaccine in the body. The chemical is called Polyfluoroalkyl substances (PFAS). It

is present in pens, utensils, pizza boxes and waterproof clothes. According to researchers, it can affect the covid-19 vaccine to a much greater extent.

- Serum Institute of India is the first indigenous company to apply to the Drugs Controller General of India (DCGI) seeking authorisation for coronavirus vaccine in the country.
- British pharmaceutical giant AstraZeneca said that it would soon start work with Russia's Gamaleya Institute to investigate whether their two coronavirus vaccine candidates could be successfully combined.
- Following directives of the union health ministry, the National Jalma Institute has developed a facility for storing Covid-19 vaccine in Agra, India. Three deep freezers capable of maintaining -70 degree Celsius temperatures have been installed.
- Pfizer- BioNtech's Corona vaccine has been approved in Canada. The process of applying vaccine has also started. Apart from this, the Corona vaccine has been approved by Pfizer in Bahrain and Singapore and BioNtech from Germany. At the same time, in the UAE, the vaccine of Chinese company Sino pharm has got approval.
- Britain, America and Canada are the countries in the world where the matter of the introduction of the corona vaccine has advanced considerably

9. Conclusion

The world is in dire need of safe, effective COVID-19 vaccine strategies due to lack of effective treatment. In 2020, scientists from all over the world, including India, have delivered many hopeful vaccines within impossible timeframe resulting in more than 160 vaccine candidate out of which some of the vaccines have been approved and thus mass vaccination drive has been started in many countries.

According to the pandemic vaccine development paradigm, the conventional vaccine development milestones are compressed from a timeframe of 10-15 years to 1-2 years, with overlapping preclinical, clinical and scale-up manufacturing processes occurring in parallel. However, as coronavirus is creating havoc in the world so the scientists, companies and laboratories are pacing up to develop vaccines.

According to WHO: "the vaccine must be suitable for all ages, pregnant, and lactating women and should provide a rapid onset of protection with a single dose and confer safety for at least up to one year of administration.

In this review article, I have summarised the importance of vaccine to eradicate the current pandemic situation, various vaccine platforms and candidates working for the development of vaccine. I have also mentioned the status of the vaccine development all over the world, which vaccines are approved and all information regarding various ongoing vaccine strategies.

The need of the hour is to develop a safe and effective COVID-19 vaccine and its successful mass implementation which can induce an appropriate immune response to terminate this pandemic. It is the universal priority to spot the international funding mechanism to support the development, manufacturing, and stockpiling of the coronavirus vaccines so that millions of lives can be saved globally from this pandemic.

The COVID-19 mass vaccination program, if successful, may be one of the greatest moments in our public health system and a great victory for science

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