Modern COVID-19 Vaccines

Kimberly Meg Pereira (ОрГМУ) 309и

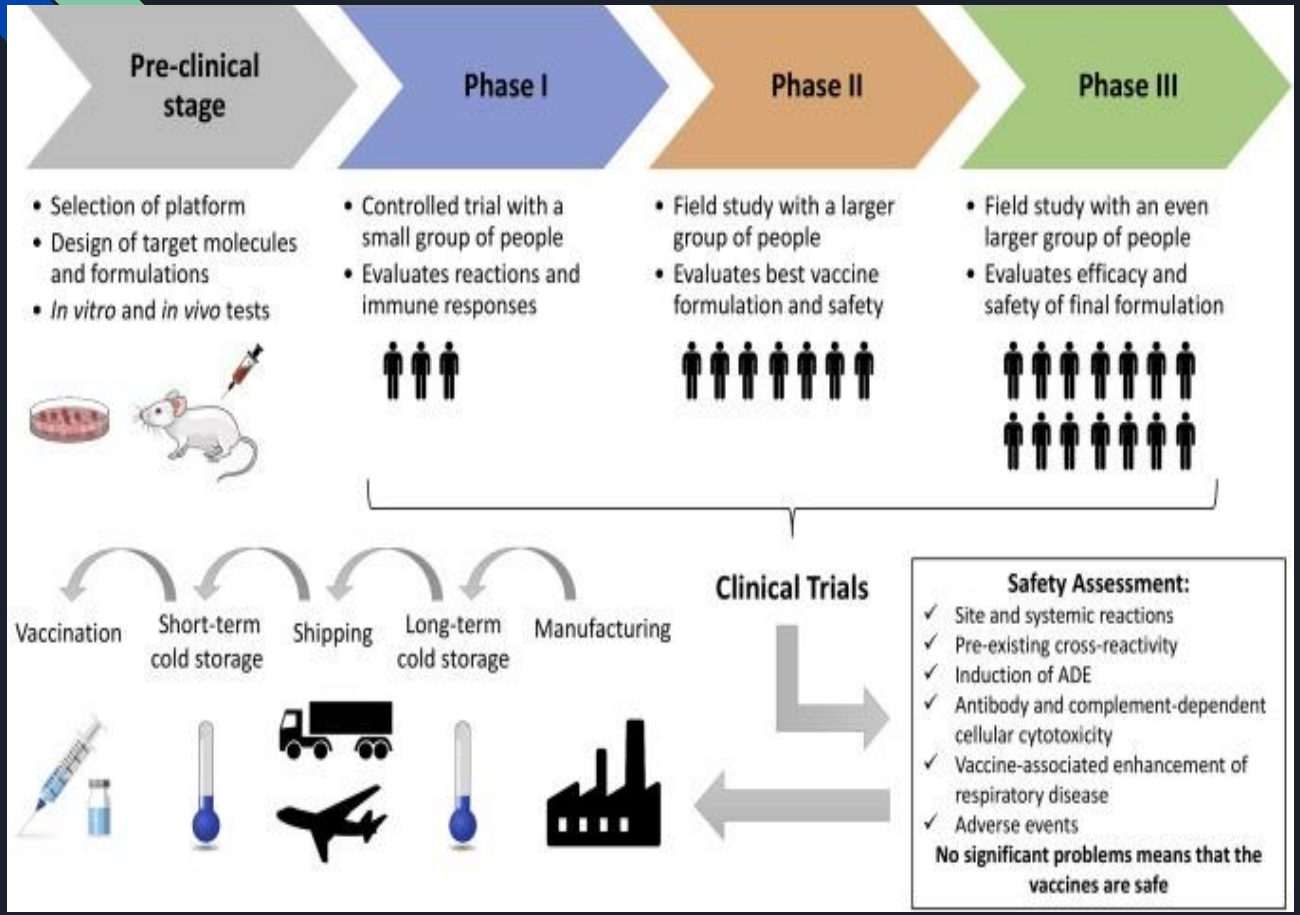
Overview

COVID-19 pandemic has resulted in millions of deaths and a social-economic crisis.

A worldwide effort was made to develop efficient vaccines for this disease.

A COVID-19 vaccine is a vaccine intended to provide acquired immunity against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19).

Stages of Vaccine Development



Vaccine design involves the selection of platforms that includes viral, viral-vector, protein, nucleic acid, or trained immunity-based strategies. Its development initiates at a pre-clinical stage, followed by clinical trials when successful. Only if clinical trials show no significant evidence of safety concerns, vaccines can be manufactured, stored, and distributed to immunize the population.

So far, regulatory authorities from many countries have approved nine vaccines with phase 3 results.

List of COVID-19 Vaccines

1. Moderna. mRNA-1273.
2. Pfizer/BioNTech. BNT162b2.
3. Janssen (Johnson & Johnson) Ad26.COV2.S.
4. Oxford/AstraZeneca. AZD1222.
5. Sputnik-V (Gam-COVID-Vac)
6. Serum Institute of India. Covishield (Oxford/AstraZeneca formulation)
7. Sinopharm (Beijing) BBIBP-CorV (Vero Cells)
8. Sinovac. CoronaVac.
9. Novavax (NVX-CoV2373) *

*This vaccine is in Phase 3 trials and has not been authorized by any country.

Vaccine Types (against COVID-19) and their Characteristics

Table 1. Summary of the characteristics of each vaccine platform.

Platform	Advantages	Disadvantages
Live-attenuated	• Elicit strong immune response • Highly established • Long-lasting protection • Do not need adjuvants	• Requires dedicated biosafety • Risk of regaining virulence • Causes reactogenicity
Inactivated	• Elicit strong immune response • Highly established • Less reactogenicity than live-attenuated	• Lower immune response than live-attenuated • Needs adjuvants
Viral-vectors	• Precise immune response • Safer than live-attenuated and inactivated vaccines	• Variable immunogenicity • Can be influenced by preexisting vector antibodies • Risk of genomic integration
Protein-based	• No biosafety concerns • Strong antibody immunogenicity • Precedent of successful vaccines • Can be formulated into virus-like particles	• Needs adjuvants • May not carry glycans similar to the viral proteins
DNA	• No biosafety concerns • Elicit reasonable immune response • Long-term stability • Can be multivalent	• Variable immunogenicity • Risk of genomic integration
RNA	• No biosafety concerns • No risk of genomic integration • Elicit strong immune response • Can be multivalent	• Possible inflammatory reaction • May require ultra-cold storage • Require delivery by lipid nanoparticles
Trained immunity-based	• Can boost the innate immune response • Already available	• Efficacy and mechanisms still not well understood • No induction of adaptive immunity memory • Reversible and short-durable

Some Vaccine Types and Their Popular Examples

1. **mRNA vaccines**
   a. Pfizer–BioNTech
   b. Moderna
2. **Adenovirus vector vaccines**
   a. Oxford–AstraZeneca
   b. Sputnik V
   c. Janssen
3. **Subunit vaccines**
   a. EpiVacCorona
   b. Novavax COVID-19 vaccine,
4. **Inactivated coronavirus vaccines**
   a. China: CoronaVac, BBIBP-CorV, and WIBP-CorV
   b. India: Covaxin
   c. Russia: CoviVac

Additional types of vaccines that are in clinical trials include virus-like particle vaccines, multiple DNA plasmid vaccines, at least two lentivirus vector vaccines, a conjugate vaccine, and a vesicular stomatitis virus displaying the SARS-CoV-2 spike protein.

Overview of some COVID-19 vaccines

Pfizer-BioNTech

Type: mRNA vaccine

For ages: People 12 years and older

Number of Shots: 2 shots Given 3 weeks (21 days) apart

When Fully Vaccinated: 2 weeks after your second shot

As far as the Delta variant, two studies reported by Public Health England that have not yet been peer reviewed showed that full vaccination after two doses is 88% effective against symptomatic disease and 96% effective against hospitalization.

Additional Dose: Recommended for moderately to severely immunocompromised people, given 4 weeks after second shot

Booster Dose: Recommended for some people who are at higher risk for COVID-19 exposure or severe illness , given 6 or more months after second shot

Efficiency: 95%

Common side effects: Chills, headache, pain, tiredness, and/or redness and swelling at the injection site, all of which generally resolve within a day or two of rest, hydration, and medications like acetaminophen. On rare occasions, the vaccine has appeared to trigger anaphylaxis.

Moderna

Type: mRNA vaccine

For ages: People 18 years and older

Number of Shots: 2 shots given 4 weeks (28 days) apart

When Fully Vaccinated: 2 weeks after your second shot

In June 2021, Moderna reported that studies showed its vaccine is effective against the Beta, Delta, Eta, and Kappa variants, although it did show it to be about two times weaker against Delta than against the original virus.

Additional Dose: Recommended for moderately to severely immunocompromised people, given 4 weeks after second shot

Booster Dose: Not recommended at this time

Efficiency : 94%

Common side effects: Chills, headache, pain, tiredness, and/or redness and swelling at the injection site, all of which generally resolve within a day or two. On rare occasions, it has appeared to trigger anaphylaxis

Johnson & Johnson’s Janssen

Type: Adenovirus viral vector vaccine

For ages: People 18 years and older

Number of Shots: 1 shot

When Fully Vaccinated: 2 weeks after your shot

Additional Dose: Not recommended at this time

Booster Dose: Not recommended at this time

Efficiency: 64.7%

Common side effects: Fatigue, fever headache, injection site pain, or myalgia (pain in a muscle or group of muscles), all of which generally resolve within a day or two. It has had noticeably milder side effects than the Pfizer and Moderna vaccines, according to the FDA report released in late February. No one suffered an allergic reaction in clinical trials for the vaccine, according to the company.

Johnson & Johnson reported effectiveness against the Delta variant, showing only a small drop in potency compared with its efficacy against the original strain of the virus, although one recent study suggested that the J&J vaccine is less effective against Delta.

Covishield

Type: Viral vector vaccine

For ages: People 18 years and above

Number of shots: 2 doses

Efficiency: 81.3 %

As far as the Delta variant, two recent studies (neither has been peer-reviewed) showed, respectively, that full vaccination after two doses is 60% effective against symptomatic disease and 93% effective against hospitalization.

Common side effects : Tenderness, pain, warmth, redness, itching, swelling or bruising at the injection site, all of which generally resolve within a day or two. Rare complication are blood clots.

Sputnik V

Type: Adenovirus viral vector vaccine

For ages: People 18 years and above

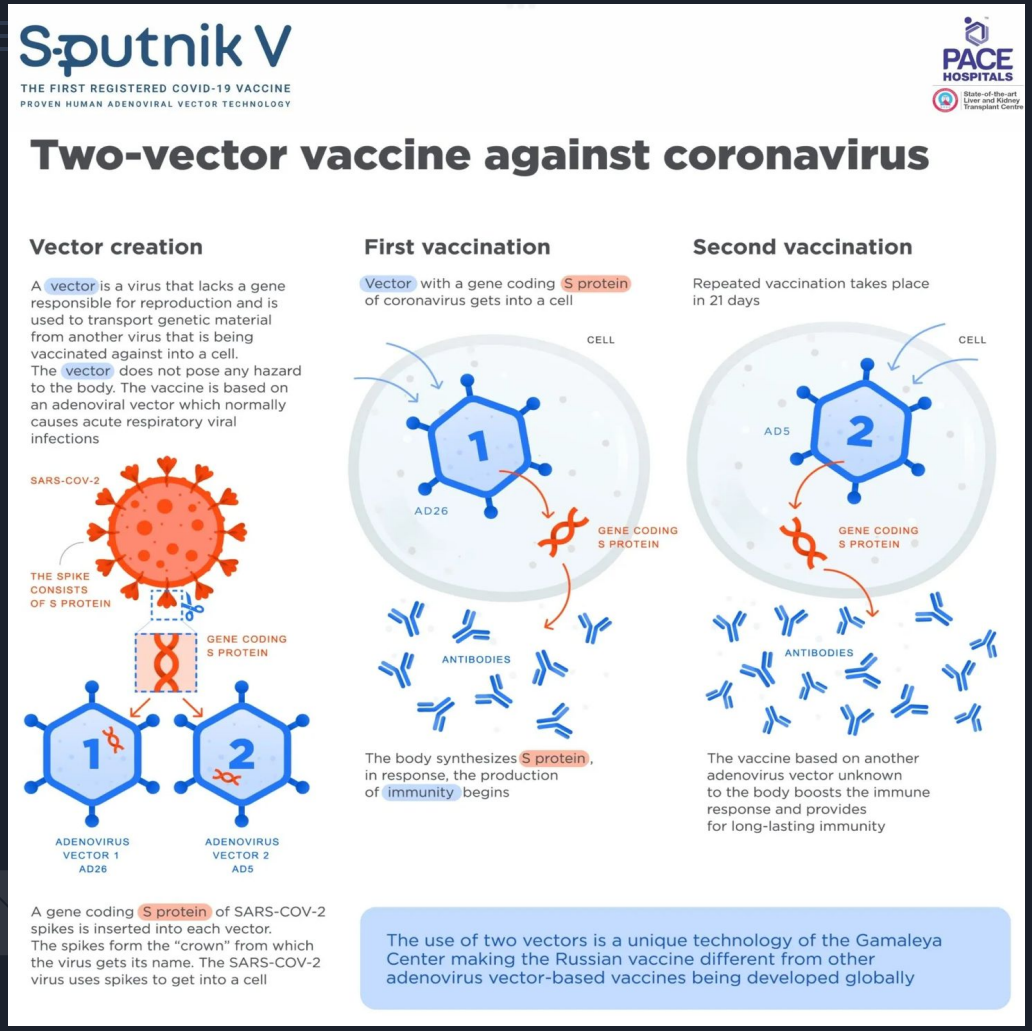
Number of shots: 2 shots given 3 weeks (21 days) apart

When Fully Vaccinated: 2 weeks after second shot

Efficiency: 91.6 %

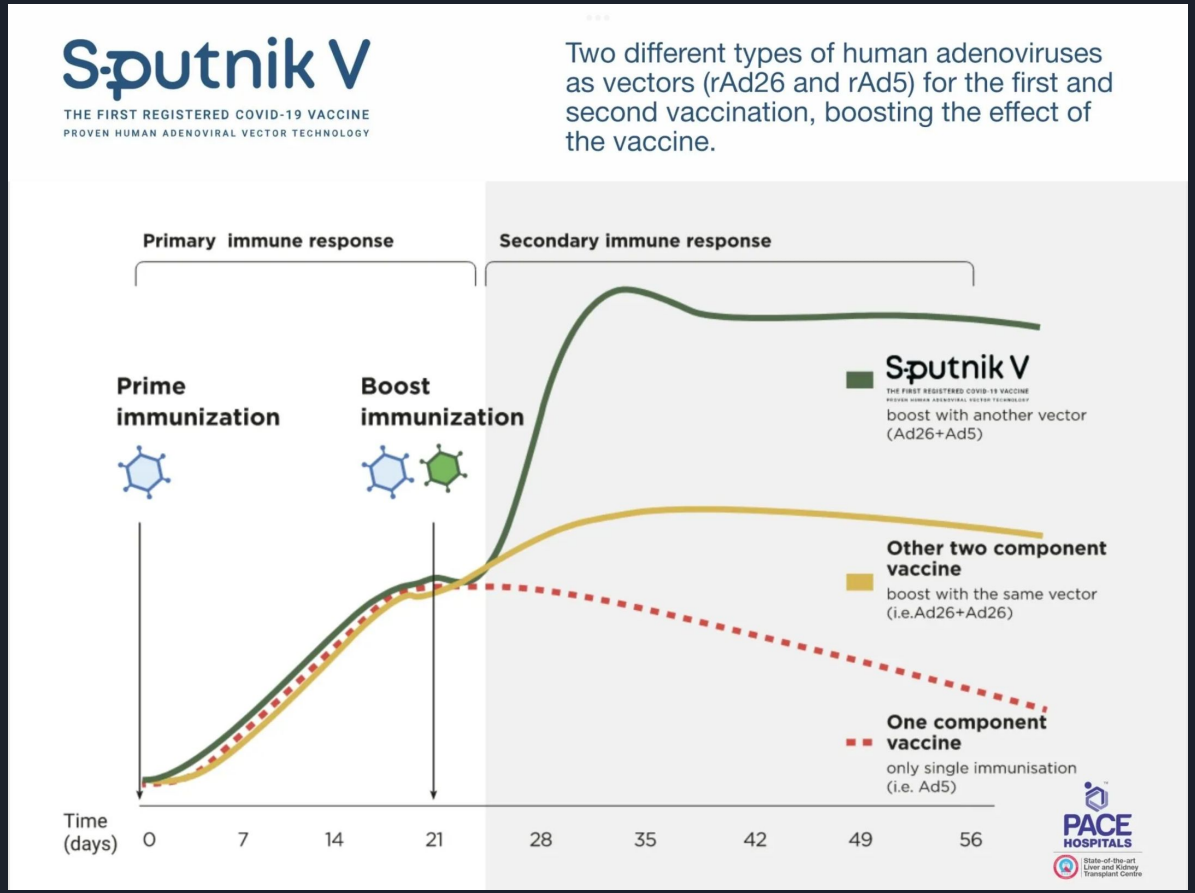
Side effects: Pain, redness, or swelling at the site of injection, Asthenia (lack of energy / abnormal physical weakness), Fatigue, Body and muscle pain, Cough and Sore throat, Runny nose, Fever and Chills, Nausea and Vomiting , Diarrhea, Headache

Sputnik V is around 83% effective against the Delta variant of coronavirus, according to the latest studies



Mechanism of Action

Sputnik V (Gam-COVID-Vac) is based on safe and effective human adenovirus vector platform using two different adenoviral vectors - Adenovirus 26 (Ad26) and Adenovirus 5 (Ad5) as an expression of SARS-CoV-2 spike protein gene.



Immune Response graph after administration of Sputnik V

Table 2
Latest information on COVID-19 vaccines with approvals and phase 3 clinical trial results.

Developer country	Developer	Vaccine name	Strategy	Regimen	Efficacy	Storage	Countries approvals	Latest publication
United States and Germany	Pfizer-Biotech	BNT162b2	mRNA	Two-dose	95 %	−80 to -60 °C	79 approvals (US, UK, EU, AR, AU, others)	Polack et al., 2020
United States and Germany	Janssen	Ad26.COV2.S	Ad26	One-dose	74.4 % (US), 64.7 % (LatAm), 52.0 % (ZA)	2 to 8 °C	35 approvals (US, EU, CA, ZA, others)	Oliver et al., 2021
United States	Moderna	mRNA-1273	mRNA	Two-dose	94.0 %	−25 to -15 °C	41 approvals (US, UK, EU, IL, others)	Baden et al., 2021
United Kingdom and Sweden	Oxford-AstraZeneca	AZD-1222	ChAdOx1	Two-dose	70.4 %	2 to 8 °C	81 approvals (UK, EU, BR, IN, MA, others)	Voysey et al., 2021
Russia	Gamaleya	Sputnik-V	Ad26, Ad5	Two-dose	91.6 %	−18 °C	55 approvals (RU, AR, AE, GN, others)	Logunov et al., 2021
China	CanSino	Ad5-nCoV (Convidecia)	Ad5	One-dose	*NA*	*NA*	4 approvals (CN, HU, MX, PK)	Zhu et al., 2020
China	Sinopharm	BBIBP-CorV	Inactivated	Two-dose	*NA*	2 to 8 °C	27 approvals (BH, EG, HU, IQ, PE, CS, AE, others)	Xia et al., 2021
China	Sinovac	CoronaVac	Inactivated	Two-dose	50.4 %	2 to 8 °C	19 approvals (BR, CL, CN, ID, TR, others)	Zhang et al., 2021
India	Bharat Biotech	BBV152 (Covaxin)	Inactivated	Two-dose	*NA*	2 to 8 °C	5 approvals (IN, IR, MA, NP, ZW)	Ella et al., 2021

AR: Argentina; AE: United Arab Emirates; AU: Australia; BH: Bahrain; BR: Brazil; CA: Canada; CL: Chile; CN: China; EG: Egypt; EU: European Union; GN: Guinea; HU: Hungary; ID: Indonesia; IL: Israel; IN: India; IR: Iran; IQ: Iraq; LatAm: Latin American; MA: Morocco; MA: Mauritius; MX: Mexico; NP: Nepal; PE: Peru; PK: Pakistan; RU: Russia; TR: Turkey; UK: United Kingdom; CS: Republic of Serbia; ZA: South Africa; ZW: Zimbabwe; LatAm: Latin America.
NA: Not available.

Conclusion

COVID-19 vaccines are crucial tools in the pandemic response and protect against severe disease and death. Vaccines provide at least some protection from infection and transmission, but not as much as the protection they provide against serious illness and death.
Vaccines are likely staying effective against variants because of the broad immune response they cause, which means that virus changes or mutations are unlikely to make vaccines completely ineffective.
One of the best ways of guarding against new variants is to continue applying tried-and-tested public health measures and rolling out vaccines.

Thank you for your attention!