Virus released from cell after assembly

Antigen-presenting cells engulf virus

T-helper cells are activated by viral peptides displayed on antigen-presenting cells

Cytotoxic T cells enabled to identify and destroy infected cells

B cells enabled to create antibodies that block virus from infecting cells

APC: antigen-presenting cells
Previous Vaccine Timeline

- **Exploratory**
  - >4 years

- **Preclinical**
  - 5-7 years

- **Clinical**
  - BLA

- **Review**
  - 1-2 years

IND: Investigational new drug
BLA: biologics license application

SARS-CoV-2 Vaccine Timeline

**Exploratory Preclinical**

**Clinical**
- Phase I
- Phase II
- Phase III

**Production**

**Review**

**IND:** Investigational new drug
**BLA:** Biologics license application

10 months to 1.5 years total.
SARS-CoV-2 Vaccine Development

1. Robust immune response
2. Potent T-lymphocyte immunity
3. Limit serious adverse events

Global Vaccine Outlook

- Phase 1: 37
- Phase 2: 27
- Phase 3: 20
- Authorized: 6
- Approved: 4*

>170 in preclinical development
>60 in clinical trials on humans
2 Currently approved via EUA pathway in the US

*2 EUA approved in US

Updated as of February 14, 2021
The New York Times. Coronavirus Vaccine Tracker

EUA: Emergency Use Authorization
SARS-CoV-2 Vaccine Platforms

- **Traditional approaches**
- **Recently licensed approaches**
- **Novel approaches**

<table>
<thead>
<tr>
<th>Platform</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live attenuated or whole inactivated vaccines</td>
<td>[Image of live attenuated or whole inactivated vaccines]</td>
</tr>
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<td>Genetic-code vaccines</td>
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<tr>
<td>Protein-based vaccines</td>
<td>[Image of protein-based vaccines]</td>
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</table>
Current SARS-CoV-2 Vaccine Landscape By Platform

Candidate Vaccines as of February 12, 2021

- **Protein subunit**: 33%
- **Viral Vector (non-replicating)**: 15%
- **DNA**: 12%
- **Inactivated Virus**: 15%
- **RNA**: 11%
- **Viral Vector (replicating)**: 5%
- **Virus Like Particle**: 3%
- **VVr + Antigen Presenting Cell**: 3%
- **VVnr + Antigen Presenting Cell**: 1%

VVr: Viral Vector replicating
VVnr: Viral Vector non-replication

https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines
# Vaccine Platform Overview

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### Pros
- Immune response has broad target range
- Given intranasally
- Familiar, proven technology
- Produced without handling live virus
- Good immune response
- High immune response
- Prime-boost regimens
- RBD-based prone to impact of antigenic drift
- Experience producing
- Large scale production

### Cons
- Time-consuming to grow
- Specific facilities for production
- Safety concerns
- Partial neutralization by existing immunity
- Prime-boost regimens
- Spike protein hard to express
- Relatively new technology
- Stability issues

### Vaccine Candidates
- Codagenix
- Indian Immunologicals Ltd.
- Sinovac
- Sinopharm
- AstraZeneca
- CanSino Biologics
- Johnson & Johnson
- Novavax
- AdaptVac
- Moderna
- Pfizer-BioNTech

MOA: Mechanism of Action

# Vaccine Platform Overview

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| **Pros**                 | • Immune response has broad target range | • Immune response has broad target range | • Produced without handling live virus | • Produced without handling live virus | • Easy and quick to design |
|                         | • Given intranasally | • Familiar, proven technology | • Familiar, proven technology | • Experience producing | • Large scale production |
|                         | • Familiar, proven technology | • Good immune response | 

| **Cons**                | • Time-consuming to grow | • Time-consuming to grow | • Partial neutralization by existing immunity | • Spike protein hard to express | • Relatively new technology |
|                        | • Specific facilities for production | • Specific facilities for production | • Prime-boost regimens | • RBD-based prone to impact of antigenic drift | • Stability issues |

| **Vaccine Candidates** | • Codagenix | • Sinovac | • AstraZeneca | • Novavax | • Moderna |
|                       | • Indian Immunologicals Ltd. | • Sinopharm | • CanSino Biologics | • AdaptVac | • Pfizer-BioNtech |

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| Pros                | • Immune response has broad target range                                      | • Immune response has broad target range                                     | • Produced without handling live virus                                        | • Produced without handling live virus                                          | • Easy and quick to design                                                |
|                     | • Given intranasally                                                          | • Familiar, proven technology                                                | • Familiar, proven technology                                                  | • Experience producing                                                         | • Large scale production                                                  |
|                     | • Familiar, proven technology                                                 | • Good immune response                                                       |                                                                                |                                                                                |                                                                                |
|                     | • Time-consuming to grow                                                      | • Time-consuming to grow                                                     | • Partial neutralization by existing immunity                                  | • Spike protein hard to express                                                | • Relatively new technology                                                |
|                     | • Specific facilities for production                                          | • Specific facilities for production                                         | • Prime-boost regimens                                                         | • RBD-based prone to impact of antigenic drift                                  | • Stability issues                                                        |
| Cons                | • Safety concerns                                                            |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Partial neutralization by existing immunity                                 |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Prime-boost regimens                                                        |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Spike protein hard to express                                               |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • RBD-based prone to impact of antigenic drift                                |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Relatively new technology                                                   |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Stability issues                                                            |                                                                                |                                                                                |                                                                                |                                                                                |
|                     | • Safety concerns                                                             |                                                                                |                                                                                |                                                                                |                                                                                |

| Vaccine Candidates  | Codagenix                                                                     | Sinovac                                                                      | AstraZeneca                                                                  | Novavax                                                                       | Moderna                                                                     |
|                     | Indian Immunologicals Ltd.                                                    | Sinopharm                                                                    | CanSino Biologics                                                            | AdaptVac                                                                      | Pfizer-BioNtech                                                            |
|                     |                                                                                |                                                                              | Johnson & Johnson                                                            |                                                                                |                                                                                |

**MOA:** Mechanism of Action

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**MOA:** Mechanism of Action  
**RBD:** Receptor binding domain  
# Vaccine Platform Overview

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MOA: Mechanism of Action

# Pertinent SARS-CoV-2 Vaccine Candidates

<table>
<thead>
<tr>
<th>Candidate Name</th>
<th>Vaccine Platform</th>
<th>Sponsor</th>
<th>Clinical Trial Phase</th>
<th>Dosing</th>
<th>Storage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNT162b2</td>
<td>mRNA-based</td>
<td>Pfizer-BioNtech</td>
<td>EUA</td>
<td>2 doses (d0, d21)</td>
<td>-70°C</td>
<td>$20/dose</td>
</tr>
<tr>
<td>mRNA-1273</td>
<td>mRNA-based</td>
<td>Moderna</td>
<td>EUA</td>
<td>2 doses (d0, d28)</td>
<td>-20°C</td>
<td>$32-37/dose</td>
</tr>
<tr>
<td>AZD1222</td>
<td>Non-replicating viral vector</td>
<td>AstraZeneca</td>
<td>Phase 3</td>
<td>2 doses (d0, d28)</td>
<td>2-8°C</td>
<td>$3-4/dose</td>
</tr>
<tr>
<td>Ad26.COV2.S</td>
<td>Non-replicating viral vector</td>
<td>Johnson&amp;Johnson</td>
<td>Phase 3</td>
<td>1 dose</td>
<td>2-8°C</td>
<td>$10/dose</td>
</tr>
<tr>
<td>NVX-CoV2373</td>
<td>Recombinant protein</td>
<td>Novavax</td>
<td>Phase 3</td>
<td>2 doses (d0, d21)</td>
<td>2-8°C</td>
<td>$16/dose</td>
</tr>
</tbody>
</table>


EUA: Emergency Use Authorization
Current and Future Challenges

Under-represented populations
- Pregnant and breastfeeding women, immunocompromised, diverse race and ethnicities

Vaccine Hesitancy
- Willingness to get COVID-19 vaccination ~63%

Phase 3 enrollment and long-term outcomes
- Many frontline workers involved in phase 3 trials → impact long term outcomes

Equitable Administration
- On top of number of vaccines, storage requirements and cost will significantly impact certain areas of the world

### EUA Vaccine FAQs

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons with a History of SARS-CoV-2 Infection</td>
<td>Vaccination regardless of prior infection</td>
</tr>
<tr>
<td>Persons with Known Current SARS-CoV-2 Infection</td>
<td>Defer vaccination until recovery and isolation discontinued</td>
</tr>
<tr>
<td>Persons Previously Received Passive Antibody Therapy</td>
<td>No data&lt;br&gt;Defer vaccination for at least 90 days to avoid vaccine interference</td>
</tr>
<tr>
<td>Immunocompromised Persons</td>
<td>No Data&lt;br&gt;Can receive vaccination unless otherwise contraindicated</td>
</tr>
<tr>
<td>Pregnant or Breastfeeding Persons</td>
<td>No data&lt;br&gt;May choose to be vaccinated&lt;br&gt;Discussion with healthcare provider</td>
</tr>
<tr>
<td>Public Health Recommendations</td>
<td>Protection not immediate or 100%&lt;br&gt;Continue to follow current distancing and protection guidance</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Severe reaction after previous dose of vaccine&lt;br&gt;Immediate reaction to previous dose of vaccine or any of its components&lt;br&gt;Immediate allergic reaction to polysorbate</td>
</tr>
</tbody>
</table>

For more information, visit [https://www.cdc.gov/vaccines/covid-19/downloads/pfizer-biontech-vaccine-what-Clinicians-need-to-know.pdf](https://www.cdc.gov/vaccines/covid-19/downloads/pfizer-biontech-vaccine-what-Clinicians-need-to-know.pdf)
• Registries for Vaccine and Breastfeeding
  • Human Breastmilk Study
    • Icahn School of Medicine at Mount Sinai
    • Investigator: Dr. Rebecca L.R. Powell
    • To sign up email: covid19humanmilkstudy@gmail.com
  • Mommy’s Milk Research Study
    • University of California at San Diego
    • To sign up email: milkstudy@health.ucsd.edu

• Registries for Pregnancy
  • C-VIPER
    • https://corona.pregistry.com/
    • Registration open February 8, 2021 → register online (NCT NCT04705116)

NEW! NCT04754594 → phase 2/3 randomized placebo-controlled trial for BNT162b2 in pregnant women
V-Safe is a smartphone app that uses texts and surveys to provide check-ins following vaccination

- Easiest way to tell the CDC of any side effects that are encountered following vaccination
- It will also set a reminder for the 2nd vaccination in the series!

You will need a smart phone and your SARS-CoV-2 vaccination information to register and use v-safe

Instructions can be found at:
V-Safe After Vaccination

<table>
<thead>
<tr>
<th>People receiving 1 or more doses in the United States*</th>
<th>Pfizer-BioNTech</th>
<th>Moderna</th>
<th>All COVID-19 vaccines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12,153,536</td>
<td>9,689,497</td>
<td>21,843,033</td>
</tr>
<tr>
<td>Registrants completing at least 1 v-safe health check-in†</td>
<td>997,042</td>
<td>1,083,174</td>
<td>2,080,216</td>
</tr>
<tr>
<td>Pregnancies reported to v-safe</td>
<td>8,633</td>
<td>6,498</td>
<td>15,131</td>
</tr>
</tbody>
</table>

*Data as of 1/24/2021
†Data as of 1/20/2021

- Most frequently reported reactions following vaccination: pain, fatigue, headache, myalgia
- Rates mostly consistent across both vaccines, numerically Moderna slightly higher reactions reported

Safety Updates

• Reports of deaths following COVID-19 vaccination in community dwelling adults aged <65 years
  • **Expected sudden cardiac death count**: 168 deaths (based on estimated background rate of sudden cardiac death = 29.6/100,000 person-years)
  • **Reported VAERS sudden cardiac death count following COVID vaccination**: 18 deaths

• Reports of deaths following COVID-19 vaccination in LTCF residents to VAERS
  • Assessment after excluding residents with positive SARS-CoV-2 test within 20 days prior 7-day post vaccination window
    • Mortality lower among vaccinated vs unvaccinated within the same facilities
    • Short term mortality likely unrelated to COVID-19 vaccination in skilled nursing facility residents

Useful Links

• CDC Website
  • https://www.cdc.gov/vaccines/covid-19/index.html

• CDC Vaccine Communication Toolkit
  • https://www.cdc.gov/vaccines/covid-19/health-systems-communication-toolkit.html

• CDC Guidance for Infection Prevention Considerations Post Vaccination

• COVID-19 Real-Time Learning Network (CDC and IDSA)
  • https://www.idsociety.org/covid-19-real-time-learning-network/

1. Get Vaccinated
2. Tell Others Why
3. Build the Confidence
SARS-CoV-2 Vaccines

General Information

A Review of Pertinent Drug Information for SARS-CoV-2

Jeannette Bouchard, PharmD
Infectious Diseases/Antimicrobial Stewardship Clinical Pharmacy Specialist
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@jlbouchard001
February 16, 2020