COVID-19 Vaccine: Technology Platform, Efficacy and Immune Protection

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BACKGROUND

Since the beginning of the Coronavirus Infectious Disease 2019 (COVID-19) pandemic, through an unprecedented global effort at vaccine development, currently we have several emergency use authorization (EUA) vaccines available and administered in US and throughout the world. Three major vaccine platforms/ technologies utilized to develop the currently available and administered vaccines. These platforms are: mRNA-based vaccines, viral vectored-based vaccines and protein-based vaccines.

Usually, it takes about 10 years to complete research and development, clinical trial and gain FDA approval for a typical vaccine. But COVID-19 vaccine development broke all records, from the beginning through end everything have been accomplished within a year. Therefore, although it may seemed rushed, every possible scientific stringency, regulatory oversight and clinical safety have been closely monitored leading to EUA of these vaccines.

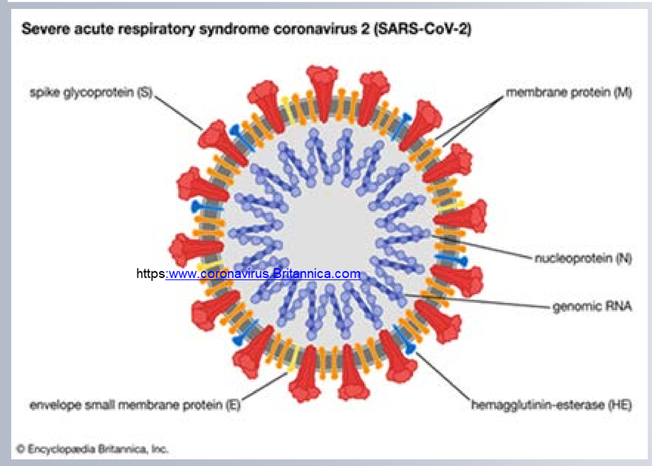
In this presentation we will look into various COVID-19 vaccine platforms, immune response and efficacy in clinical trial and vaccinated individuals with approval. We will also analyze available information regarding vaccine efficacy/ protection against the emergent COVID-19 variants of concern (VOC).

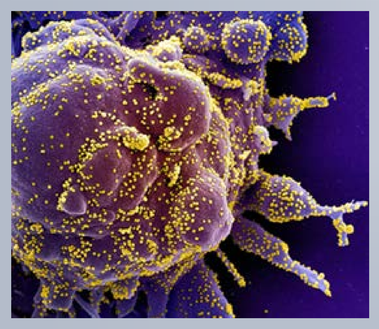
OBJECTIVES

The purpose of this presentation is to provide an overview of the various vaccines formulations for coronavirus infectious disease 2019 (COVID-19). We will discuss various technology platforms used for rapid development of the vaccines, types of immune response generated, efficacy and vaccine-induced immune protection particularly against the emerging variants.

METHODS

COVID-19 related keyword search and review of primary and tertiary literatures available in medRxiv, PubMed, CDC and NIAID database was employed. The search specifically focused on Covid-19 vaccine clinical trial data and vaccine-induced immune protection against infection.





EM of a cell heavily infected with SARS-COV-2 virus particles, isolated from a patient sample. NIAID.

Fig 1. SARS-CoV-2 Structure, and Cell Infected with the Viral Particles.

VACCINE DATA

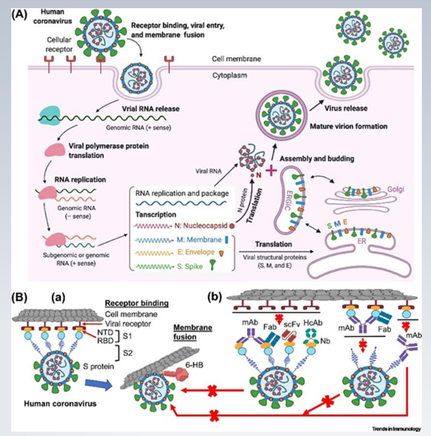


Fig 2. SARS-CoV-2 Life Cycle and Structure Important for Vaccine and Drug Development.

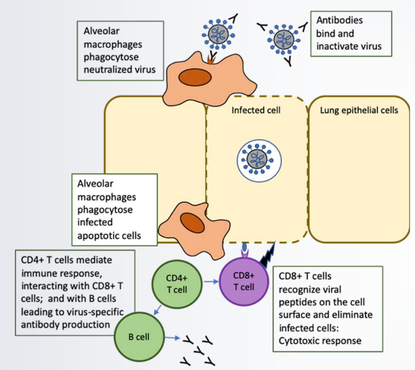


Fig 3. The Trinity of COVID-19: Immunity, Inflammation and Intervention

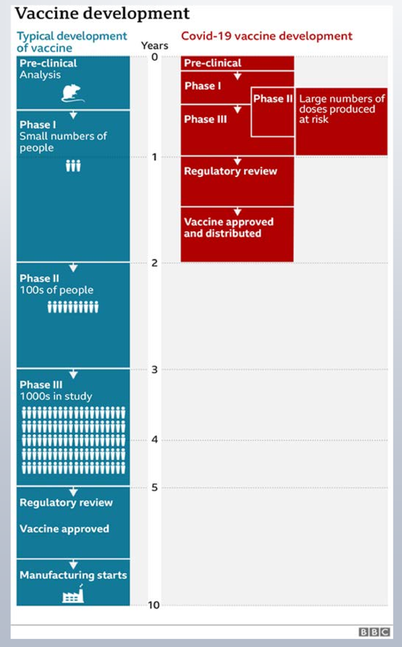


Fig 4. COVID-19 Vaccine Development Timeline Compared to Traditional Vaccines .

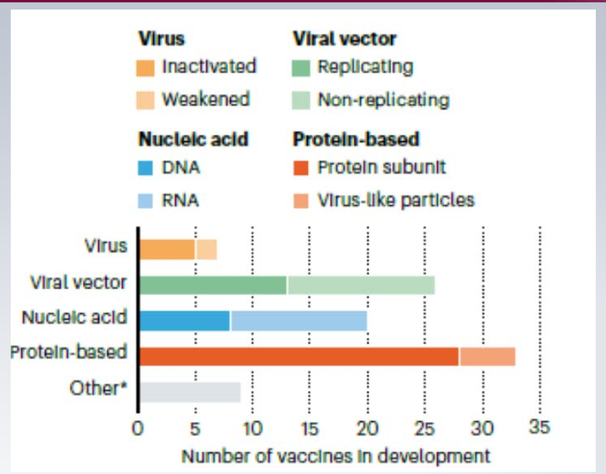


Fig 5. COVID-19 Vaccine Platforms.

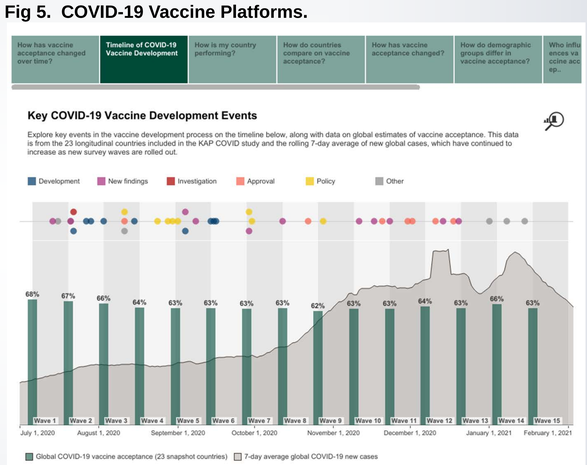


Fig 6. Relationship Between Vaccine Development, Vaccine Acceptance and Infection

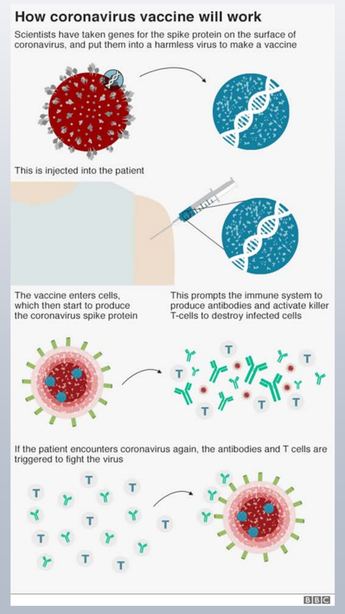


Fig 6. Proposed Mechanisms of Vaccine-induced Immune Response

COVID-19 Vaccine Formulations

- mRNA-based: Moderna, Pfizer-BioNTech
  - S-protein mRNA in lipid nanoparticle formulation
- Viral vector-based: genetically engineered virus with 'S protein' DNA
  - Adenovirus: AstraZeneca, Johnson & Johnson (J & J) , Gamaleya, CanSino Biologics
- Protein-based vaccines:
  - Novavax, PittcoVac -S protein specific
- DNA vaccine
  - Inovio
- Killed virus vaccine
  - Covaxin, Bharat Biotech, India

COVID-19 Vaccine Schedules

- Pfizer/BioNtech: 2 shots 21d apart, 95% protection
- Moderna: 2 shots 28d apart, 94% protection
- Johnson & Johnson: 1 shot, 85% efficacy against severe infection
- AstraZeneca: 2 shots, 28d apart, ~70 (60-90)% efficacy
- Sputnik V: 2-dose 28d apart, 95% efficacy
- Covaxin-killed virus vaccine, Bharat Biotech & ICMR, 2 doses 14d apart

Safety and Efficacy of COVID-19 Vaccines

- All three vaccines Moderna, Pfizer and J & J are safe with minimum adverse reactions
- Pfizer and Moderna vaccines work in population with 90% effective at preventing infection, including asymptomatic infection
- These vaccines generated robust, neutralizing & long-lasting Ab lasting over >6 months, & protection could last up to 2 years
- These vaccines also generated T cell responses important in clearing of the virus infection
- Pfizer Vaccine generated antibody response in pregnant and lactating women, and well-tolerated
- Pfizer vaccine is also safe and effective in young adolescents
- Pfizer, J & J and Moderna vaccines are protective against the emerging variants with varying degrees
- Both Pfizer and J & J vaccine effective against S. African and UK variant

CONCLUSION

- Several effective, and well-tolerated COVID-19 vaccines have been developed in a record time.
- The vaccine technology platform ranges from lipid nanoparticle-mRNA, adenoviral vector-mediated, protein vaccine and killed virus vaccine.
- All the vaccine formulations target 'S' protein, ligand for ACE2 receptor, critically important for blocking the infection.
- Vaccines induced robust and protective immune responses in wide age group individuals, and ethnicity.
- Vaccines confer significant protection against both asymptomatic, and severe infection, thus preventing hospitalization and death.
- Vaccine-induced immunity includes both B and T cell responses with memory function for long-term protection.
- Early results indicate that these vaccines also confer significant protection against the emerging variants.
- Even with available effective vaccines against COVID-19, 'vaccine hesitancy' in US and around the world remains as a concern for achieving 'herd immunity' for defeating the pandemic.