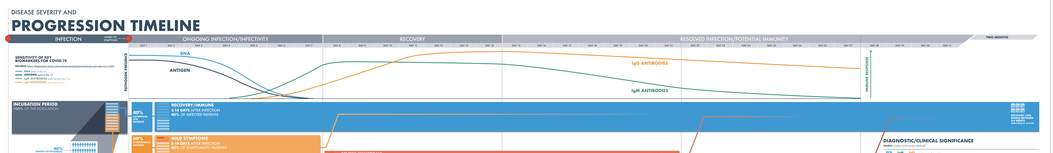
CHARTING A COMPLEX WORLD.
TECHATLAS
A DIVISION OF RACAPITAL

COVID-19 (CORONAVIRUS) SEASONAL BOOSTERS

UPDATED: MAY 13, 2022
Visit www.techatlas.com/covid19 for latest version.
Anything wrong/outdated? Please contact zach@techatlas@racap.com.
Strategic Overview & Instructions on How to Use This map

DISEASE SEVERITY AND PROGRESSION TIMELINE



THE EMERGENCE OF NEW VARIANTS

As SARS-CoV-2 spreads throughout various populations and geographies, the virus can make errors when it makes copies of itself. These errors are point mutations (single letters and changes in the genetic sequence) or strand deletions, or simply deletions, or strand insertions. Mutations in these locations that increase transmission or escape from the host's immune response. From late 2020 to early 2021, three SARS-CoV-2 variants have become increasingly prevalent worldwide (UK variant, South Africa variant, and the Brazil variant). Each variant has a different combination of mutations that affect transmissibility, immune response, and severity of the disease. Some of these mutations have been well-studied (such as those in the Spike Protein). While the current generation of vaccines appears sufficiently effective against general disease and hospitalizations as of Spring 2021, novel Variants Under Investigation (VUI) or Variants of Concern (VOC) could emerge that could significantly reduce the efficacy of current vaccines.

Alpha variant (known as 20/501Y.V1, VOC 2020/12/01, or B.1.1.7)

- First detected in the UK in September 2020 and quickly became the dominant variant worldwide.
- B.1.1.7 is associated with rapidly increasing cases and data suggests a possible increased risk of death. Preliminary data suggests that vaccine-induced immunity to earlier lineages may not fully protect against infection by B.1.1.7, but should still be effective against severe disease. Pfizer's efficacy data against B.1.1.7 is consistent with that observed against the classic variant of SARS-CoV-2 in the Spike (S) glycoprotein.
- **Moderna vaccine candidate's** 94% efficacy against the common strain is 87% effective against the South Africa strain.

Mutations:
- **N501Y mutation** the amino acid asparagine (N) has been replaced with tyrosine (Y) in the receptor binding domain (RBD) of the Spike protein. This mutation affects how the virus binds to its target cell.
- **69/70 deletion** occurred spontaneously many times and first appeared in the United States in March 2020.
- **P681H mutation** uses the CUG first codon(gene) site, a site in the genome that is unusual for SARS-CoV-2 and has been associated with increased transmissibility in other coronaviruses. This mutation has emerged spontaneously multiple times.

Beta variant (known as 20/501Y.V2 or B.1.351)

- First identified in South Africa in Oct 2020 and has been reported in the US as of Jan 2021.
- Data suggests that the Beta variant is the SARS-CoV-2 variant that is the most resistant to vaccine efficacy (data suggests that vaccine developed against the common strain of SARS-CoV-2 may have decreased efficacy against the new variant).
- **Moderna vaccine candidate's** 94% efficacy against the common strain is 60% effective against the South Africa strain.
- **J&J vaccine candidate's** 72% efficacy against the common strain is 57% effective against the South Africa strain.

Mutations:
- Mutations in the spike protein receptor binding domain: **K417N**
- **E484K**
- **N501Y**

Gamma variant (known as P.1)

- First identified in travelers from Brazil in Jan 2021 and has been reported in the US as of the end of 2021.
- Data suggests that the Gamma variant may be more resistant than the South Africa variant to vaccine efficacy.
- **J&J vaccine candidate's** 72% efficacy against the common strain is 64% effective against the strains predominant in Latin America and South Africa.

Mutations:
- Mutations in the spike protein receptor binding domain: **K417T**
- **E484K**
- **N501Y**

Delta variant (known as B.1.617)

- First detected in India in October 2020, detection began increasing in frequency in Bangladesh, India in January 2021 and spread to the United Kingdom, Portugal, and Russia by April 2021. Cases in India increased 6-fold between the end of February and the end of April 2021 and now is responsible for 70% of cases in the United States. There is evidence to suggest that B.1.617.2 is more transmissible than other variants, including the Alpha variant, and may be more resistant to some vaccines. Data suggests that up to 3 times levels of neutralizing antibodies generated by vaccinated individuals against B.1.617.2 for the original strain are required to achieve the same level of neutralization against the Alpha variant. Preliminary data suggests that vaccine efficacy against infection to the Delta variant. Reports out of various countries on PFIZER/BNT and MODERNA 60%-88% effectiveness against symptomatic disease, and 80% effectiveness against severe disease and hospitalization.

Mutations:
- **L452R** (also found in Epsilon, Iota, Lambda, and Kappa variants)
- **T478K**
- **P681R**
- **D950N**

Lambda Variant (known as C.37)

- First detected in Peru last summer, it was classified by the WHO as a variant of interest (VOI) 21 There is some evidence that it has increased infectivity and immune escape from sera based on a study out of Chile. The first cases were detected in the US in late 2021.

Mutations:
- Multiple mutations in the spike protein including:
- **L452Q**
- **F490S**
- **D614G** (also found in Alpha, beta, gamma, and delta variants)

Mu Variant (known as B.1.621)

- First detected in Colombia in January 2021, and was detected in 39 countries. It was classified as a "variant of interest" by the World Health Organization (WHO) on August 30, 2021, based on its ability to evade immunity. Cases in the US and Delta variant, but the threat of becoming the dominant strain is waning. Reports suggest that it is most similar to the Beta variant in its ability to evade immunity from vaccines. Data suggests that it may be more resistant than other variants due to their increased transmissibility and concerns of ability to evade immunity.

Mutations:
- Multiple mutations in the spike protein including:
- **T95I**
- **Y144S**
- **R346K**
- **E484K**
- **D614G** (found in all variants)
- **P681H**
- **D950N**

Omicron Variant (known as B.1.1.529) (comprised of siblings BA.1, BA.1.1, and BA.2)

- First detected in South Africa and reported to the WHO in November 2021. The variant has a large number of mutations, some of which have been seen in other variants that have been studied to affect the virus's ability to infect cells (Delta and Beta VOC), and there is especially a lot of overlap with the alpha variant. but the theory is that the mutations on Omicron may be more worrisome than those on other variants. Preliminary data suggests that Omicron may be more transmissible than other variants, including the Delta variant, and may be better at evading immunity. Data suggests that Omicron may be more resistant to some monoclonal antibody treatments in place once a vaccine is available to protect high-risk individuals (e.g., elderly and/or immunocompromised), and may be more resistant to vaccine-induced immunity. Preliminary data suggests that infections caused by Omicron are less severe than infections caused by other variants of concern, with fewer hospitalizations and fewer instances of severe illness requiring treatment in the intensive care unit, often with the use of mechanical ventilation, and have the highest risk of death from COVID-19. AFEDS is common for hospitalized patients with COVID-19 (20-42%) and initial labored breathing can quickly progress to ARDS and ICU admission. In addition to lung injury, ARDS is also associated with kidney, liver, and heart complications, which can also increase the risk of mortality[A-F].

Mutations:
- Multiple mutations in the spike protein including:
- **S371L**
- **S373P**
- **S375F**
- **T376A**
- **D405N**
- **R408S**
- **K417N**
- **N440K**
- **G446S**
- **S477N**
- **T478K**
- **E484A**
- **Q493R**
- **G496S**
- **Q498R**
- **N501Y**
- **Y505H**
- **T547K**
- **D614G**
- **H655Y**
- **N679K**
- **P681H**
- **N764K**
- **D796Y**
- **N856K**
- **Q954H**
- **N969K**
- **L981F**

COVID-19 VACCINES

To save lives, we need vaccines to prevent infection and drugs to treat people who become infected. Fortunately, several have been developed and proven successful, and many of both are still in development.

COVID-19 DISEASE OVERVIEW

SYMPTOMS:
Fever, cough, fatigue, and shortness of breath are the major symptoms associated with COVID-19. The CDC also includes loss of taste or smell, chills, muscle pain, headache, and sore throat as symptoms to watch for. While other symptoms have been reported, they occur much less frequently.

COVID-19 SYMPTOMS[1]

COVID-19 US CASES, BY AGE

Younger people make up majority of the cases, while older people disproportionately get serious COVID-19 and die.

DISEASE PROGRESSION:

PRE-INFECTION
COVID-19 can be prevented through the use of basic precautions and (in the future) an effective vaccine.

POST-EXPOSURE
After exposure to SARS-CoV-2, it takes several days for symptoms to develop. During this incubation period, the infected person is able to transmit the virus despite being unaware of their illness. This is why "social distancing" and masks are so important. Once noticed symptoms, and a mask something are critical. Most people develop symptoms between 2-14 days post-infection, with the majority developing symptoms by 5 days[2].

If we had a therapy that was safe, efficacious, and easy to administer, it could be given to people who have cases like contact with infected individuals (such as healthcare workers who have had a "needle stick" from Person Transmitting Infection). This kind of treatment is called post-exposure prophylaxis, and while there are currently many ongoing trials in this space, no medications are yet approved for this purpose. These medications would need to be taken within half-an-hour of exposure to be effective[3]. Vaccines are currently being tested for this purpose.

MILD
Most patients who develop COVID-19 have a mild disease course and are able to manage their symptoms at home using over-the-counter medications that relieve pain and/or reduce fever (e.g. Tylenol/acetaminophen or Advil/ibuprofen). If you are diagnosed with COVID-19, please follow the advice of your healthcare professional.

Some "asymptomatic" patients with COVID-19 may not develop any noticeable symptoms and may not realize they have been infected. Because these individuals can still spread the virus, everyone should employ basic protective measures like social distancing, hand washing, and mask wearing (obviously none of those are necessary if you live by yourself and never see anyone else, though washing hands is still nice).

HOSPITALIZATION
Some patients who develop COVID-19 symptoms become seriously ill 11 out of every 1 [illegible] Some of the most common reasons for hospitalization are difficulty breathing, and must be admitted in the hospital with these symptoms. Older people (65 years old) and those with other medical issues are most at risk of developing serious illness. Some identified risk factors include cardiovascular disease, diabetes, high blood pressure (hypertension), chronic lung disease, cancer, and chronic kidney disease (CKD). Typically, hospitalized patients have difficulty breathing and decreased levels of oxygen in their blood, requiring administration of supplemental oxygen[4].

Severe cases of COVID-19 can lead to "acute respiratory distress syndrome" (ARDS), meaning fluid builds up in the lungs, diminishing their capacity to absorb oxygen. Patients with severe ARDS are typically managed in the intensive care unit, often with the use of mechanical ventilation, and have the highest risk of death from COVID-19. ARDS is common for hospitalized patients with COVID-19 (20-42%) and initial labored breathing can quickly progress to ARDS and ICU admission. In addition to lung injury, ARDS is also associated with kidney, liver, and heart complications, which can also increase the risk of mortality[A-F].

MAP LEGEND

	Preclinical Trial	EUA	Emergency Use Authorization
	Clinical Trial	CMA	Conditional Marketed Trial
	Approved Therapeutic	IND	Investigator-Sponsored Trial
	Discontinued Therapeutic		
	Repurposed Therapeutic	ORA	Oral Delivery
	Prophylactic Treatment	SQ	Subcutaneous Delivery
	Therapeutic Treatment Regardless of Hospitalization	IV	Intravenous Delivery
	Treatment in Hospital Setting Only	IM	Intramuscular Delivery
	One Dose Vaccine	INHALATION	Inhaled Delivery
	Two Dose Vaccine	TOPICAL	Topical Delivery
	In collaboration with BARDA	CHANGES HIGHLIGHTED IN YELLOW	
	In collaboration with CEPI	CLICK TO SEE PAGE UPDATE LOG	
	Recognized by Operation Warp Speed (OWS)		

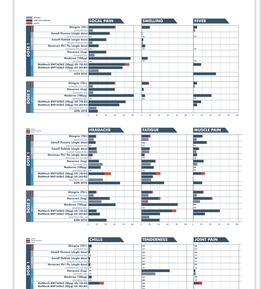
This map is a compilation of the biotech industry's effort to rid the world of COVID-19.

Our visualization aims to convey not only individual innovations from specific companies but also the collective effort and sheer hustle of the entire industry.

The legacy of COVID-19 will hopefully include not only new treatments for an acute viral illness but also a greater appreciation of what society can accomplish when we unite against a common foe. We've already achieved remarkable innovations in many diseases: hepatitis C, HIV, melanoma, breast cancer, and cystic fibrosis, to name a few. What we need now is a sustained, collective effort to make medical advances available to everyone instead of overburdening patients with excessive out-of-pocket costs that discourage them from receiving appropriate care. This will require fundamentally reforming America's insurance system, building on the recent patches put in place after payers initially refused to cover COVID-19 testing and the uninsured were overwhelmed by the cost of hospitalization.

The Biotech Social Contract, as described in **The Great American Drug Deal**, affirms that we do not have to choose between innovation and affordability. We as a society can rise to the challenge tackling all human diseases just as we have COVID-19, making investments that will permanently upgrade our health and that of future generations.

COVID-19 VACCINES: TOLERABILITY


LOCAL PAIN
SWELLING
FEVER
FATIGUE
HEADACHE
NAUSEA
MUSCLE PAIN
CHILLS
TENDERNESS
JOINT PAIN
JOINT STIFFNESS
Moderna mRNA-1273
Pfizer BNT162b2
J&J Janssen Ad26.COV2.S
AstraZeneca/Oxford ChAdOx1 nCoV-19
Novavax NVX-CoV2373
Sinovac CoronaVac
Sinopharm BIBP
Sinopharm WIV04
Bharat Biotech Covaxin
Gamaleya Sputnik V
CanSino Ad5-nCoV
Medicago CoVLP
Clover SCB-2019
Sanofi/GSK
Novavax NVX-CoV2373 (Omicron)
Moderna mRNA-1273.211 (Omicron)
Pfizer/BioNTech BNT162b2 (Omicron)
Moderna mRNA-1273.351 (Beta)
Pfizer/BioNTech BNT162b2 (Beta)
Moderna mRNA-1273.214 (Omicron BA.1 + BA.2)
Pfizer/BioNTech BNT162b2 (Omicron BA.1 + BA.2)
Moderna mRNA-1273.214 (Omicron BA.4 + BA.5)
Pfizer/BioNTech BNT162b2 (Omicron BA.4 + BA.5)
Moderna mRNA-1273.222 (Omicron BA.4 + BA.5)
Pfizer/BioNTech BNT162b2 (Omicron BA.4 + BA.5)
Moderna mRNA-1273.529 (Omicron BA.2.12.1)
Pfizer/BioNTech BNT162b2 (Omicron BA.2.12.1)
Moderna mRNA-1273.529 (Omicron BA.2.75)
Pfizer/BioNTech BNT162b2 (Omicron BA.2.75)
Moderna mRNA-1273.529