Covid-19 Vaccines Efficacy

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College of Science and Technology, Bellevue University

DSC500-T301: Introduction to Data Science (2227)

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INTRODUCTION

What is known about COVID-19?

Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. The best way to prevent and slow down transmission is to be well informed about the disease and how the virus spreads. Preventing the infection can be done by following - staying at least 6 feet apart from others, wearing a properly fitted mask, and washing hands or using an alcohol-based rub frequently.

COVID-19 vaccination will help protect you by building immunity without the risk of severe illness and vaccination is one measure to help stop the pandemic.

How Covid-19 Vaccines work ?

Coronaviruses, like the one that causes COVID-19, are named for the crown-like spikes on their surface, called spike proteins. These spike proteins are ideal targets for vaccines. Messenger RNA, or mRNA, is genetic material that tells your body how to make proteins. The vaccine is made of mRNA wrapped in a coating that makes delivery easy and keeps the body from damaging it. The mRNA in the vaccine teaches your cells how to make copies of the spike protein. If you are exposed to the real virus later, your body will recognize it and know how to fight it off.

Three vaccines have been approved or received Emergency Use Authorization from the Food and Drug Administration named Pfizer/Comirnaty, Moderna, and Janssen (Johnson & Johnson). All three COVID-19 vaccines are safe and highly effective against serious illness, hospitalization, and death. Pfizer and Moderna are messenger RNA vaccines, also called mRNA vaccines, which essentially teach the cells to recognize COVID like a computer program. The Johnson & Johnson vaccine is based on the virus's genetic instructions for building the spike protein. But unlike the Pfizer-BioNTech and Moderna vaccines, which store the instructions in single-stranded RNA, the Johnson & Johnson vaccine uses double-stranded DNA. It can be refrigerated above freezing for months, although one downside is it's less effective than the MRNA options.

The Pfizer/Comirnaty and Moderna vaccines require 2 doses given at least 3-4 weeks apart. People should get both doses to be fully vaccinated in order to be effective. Where as Johnson & Johnson (J&J) is only 1 dose.

The project aims to convey the analysis of different ongoing vaccination programs within United States of America by using all publications, reports, and news articles and review all available data to find how effective vaccines are at achieving multiple outcomes.

The objectives for the following project to prove there is no best vaccine. All the vaccines are effective, particularly at preventing serious disease. Because trials were conducted differently at different times, effectiveness figures cannot be directly compared.

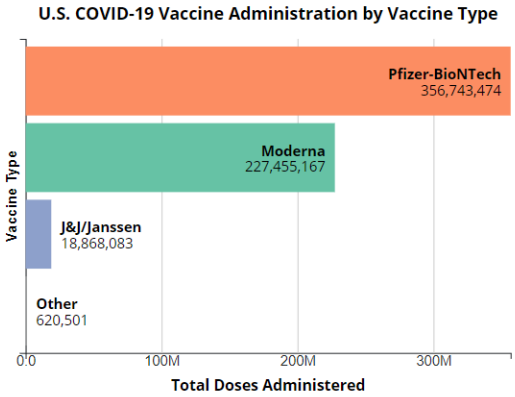
Analysis

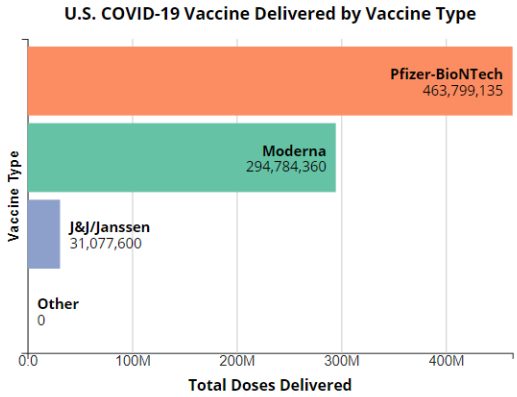
Areas of research and factors evaluated:

- Vaccine Categories
- U.S. COVID-19 Vaccine Effectiveness
- US Covid-19 Vaccine Distribution by State
- Vaccines Components
- COVID-19 Vaccine Efficacy
- COVID-19 Vaccine common side effects
- U.S. COVID-19 Vaccine Adverse Effects - Pfizer vs Moderna
- COVID-19 Vaccine - A study by CDC
- COVID-19 Vaccine - Interest Over time

Vaccine Categories

Below charts indicate the U.S. COVID-19 Vaccine Administration by Vaccine Type. These charts are prepared from the data published by CDC as of July 2022 (https://covid.cdc.gov/covid-data-tracker/#vaccinations).

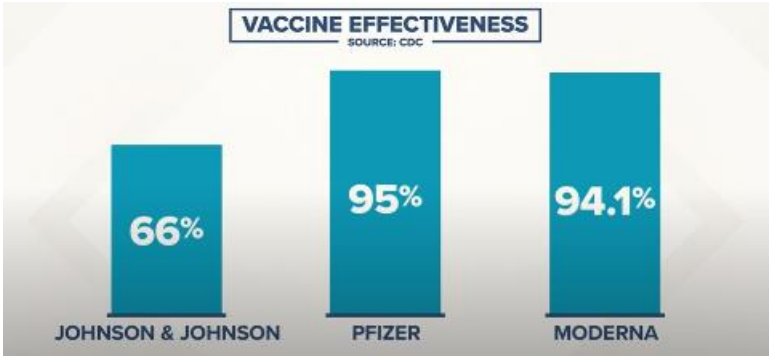




Inference: As per the charts above, Pfizer vaccines numbers administered are high, compare to Moderna and Janssen. As per the second chart Pfizer has got more doses delivered, that explains why we see pfizer is widely administered vaccine in USA. Pfizer/BioNTech has gained more popularity due to its better manufacturing capabilities abilities, so they are making more vaccines and the same is procured and distributed by US Federal government to all its jurisdictions.

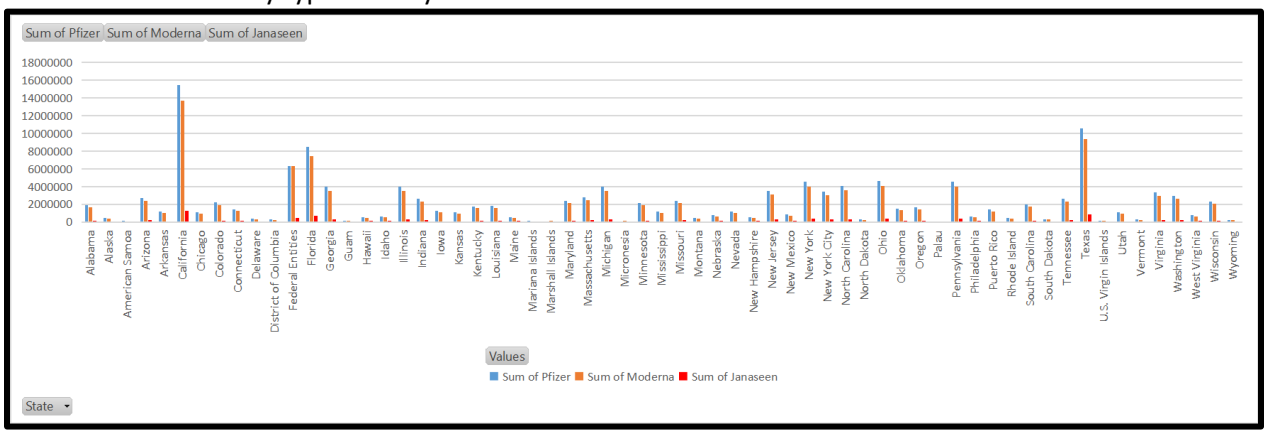
U.S. COVID-19 Vaccine Effectiveness (Source CDC) :

As per the clinical trials done by the respective vaccine companies and also as quoted by Dr. Linda Bell, State Epidemiologist for South Carolina's Department of Health and Environmental Control in an interview with WCNC, it is unfair to compare vaccine efficacy from scientific standpoint as they were tested in different points in time. They were tested in different populations of people when there were different strains circulating in those different populations of people.



US Covid-19 Vaccine Distribution by State

Vaccine Distribution by types and by States.



Inference: As per FDA briefings, it is approved Pfizer-BioNTech on Dec 10,2020 and Moderna on Dec 17,2020 for emergency use. Hence it is evident that the testing done possibly on different strains circulating in those different populations of people.
Pfizer and Moderna are distributed to states by federal government hence you see the # of people vaccinated with Pfizer and Moderna are more. Pfizer distribution started on 12/14/2020, Moderna on 12/21/2020 where as Jansen is March 2021. Also news about blood clotting events for Jansen has kept the distribution on hold. Between Pfizer and Moderna, Pfizer has more numbers and make it popular.

Vaccines Components

The vaccines developed by Pfizer-BioNTech and Moderna take advantage of messenger RNA (mRNA), which instructs cells to produce a protein on the surface of the virus. The immune system recognizes those vaccine-triggered spike proteins as invaders and creates antibodies to block future attacks of the virus that causes COVID-19.
Moderna's vaccine uses **100 micrograms of RNA** per dose, while **Pfizer-BioNTech's** shot uses only **30 micrograms** making it easier to produce and less expensive. That should enable Pfizer-BioNTech to increase production of their vaccine more quickly than Moderna which is evident pfizer vaccinated population is more than others in USA.

COVID-19 Vaccine Efficacy :

Data available today consist of clinical trials and several quasi-observational studies

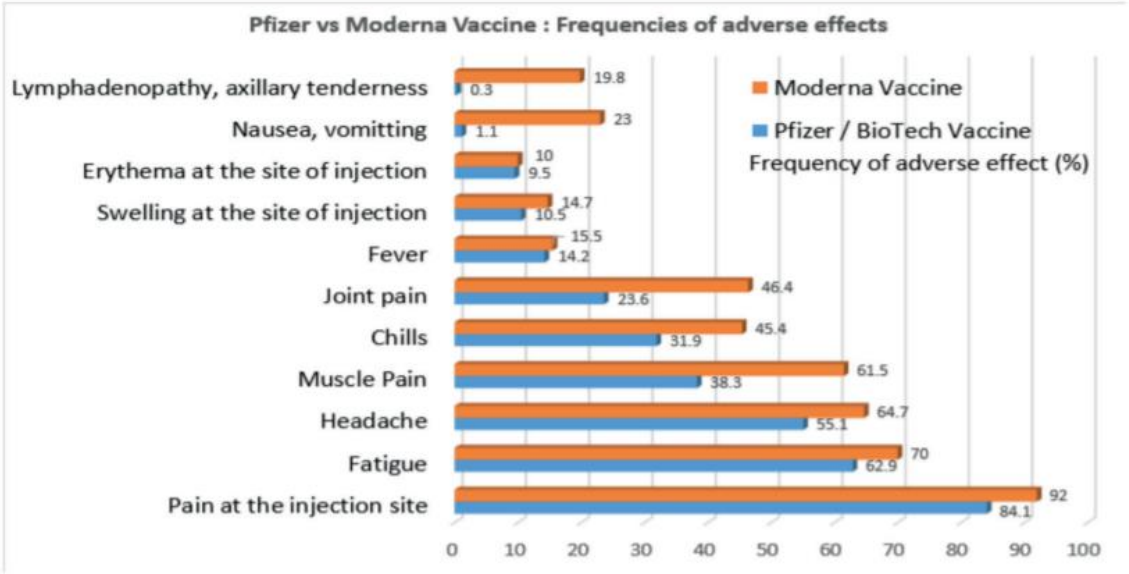
	Symptomatic disease: any	Severe disease: any	Symptomatic disease:D614G		Infection: D614G		Asymptomatic: any	Asymptomatic: B.1.1.7	Severe disease: D614G		Infection: B.1.1.7	Symptomatic disease: B.1.1.7	Severe disease: B.1.1.7	Infection: B.1.351	Symptomatic disease: B.1.351	Severe disease: B.1.351	Symptomatic disease: P.1	Severe disease: P.1
Vaccine	Complete regimen	Complete regimen	1st dose	Complete regimen	1st dose	Complete regimen	Complete regimen	Complete regimen	1st dose	Complete regimen	Complete regimen	Complete regimen	Complete regimen	Complete regimen	Complete regimen	Complete regimen	Complete regimen	Complete regimen
Pfizer-BioNTech		Israel national: 97.5% (97.1% to 97.8%)	Trial (Day 0-21): 52% (29.5% to 68.4%) Israel SHEBA (Day 15-28): 85% (71% to 92%) Israel CLALIT (Day 14-20): 57% (50% to 63%) Israel Maccabi (Day 13-24): 51.4% (-7.2% to 78.0%) England (Day 28+, 80+ yrs): 57% (48% to 63%)	Trial (original): 94.6% (90.3% to 97.6%) Trial (updated): 91.3% (89.0% to 93.2%) Israel CLALIT: 94% (87 to 98%)[1] England (80+ yrs): 88% (84% to 90%)	UK SIREN (Day 21+): 72% (58% to 86%) Israel SHEBA (Day 15-28): 75% (72% to 84%) Israel CLALIT (Day 14-20): 46% (40% to 51%)	UK SIREN: 86% (76% to 97%) Israel CLALIT: 92% (88 to 95%)		Israel National: 91.5% (90.7% to 92.2%)	Trial: 100% (-52% to 100%) Israel CLALIT (Day 14-21): 62% (39% to 80%)	Trial: 75% (-152.6% to 99.5%) Israel CLALIT: 92% (75% to 100%)	Qatar: 89.5% (85.9% to 92.3%)	Israel national: 97.0% (96.7% to 97.2%)	Qatar: 100.0% (81.7% to 100.0%)	Qatar: 75% (70.5% to 78.9%)	Trial (SA): 100% (53.5% to 100.0%)	Qatar: 100.0 (73.7–100.0)		
Moderna				Trial: 94.1% (89.3% to 96.8%)	Trial (Day 0-21): 89.6% (85.2% to 92.6%)					Trial: 100% (NE)								

Based on the published details, it is evident that Pfizer has more studies done on multiple variants and overall efficacy rate of 95% which probably is one of the key factors to gain people confidence thus reducing hesitancy rate among people of United states of America.

COVID-19 Vaccine common side effects

The percentage of these adverse effects is reported to be lower with the Pfizer/BioNTech vaccine than with the Moderna vaccine, however the Moderna vaccine compared to the Pfizer vaccine is easier to transport and store because it is less temperature sensitive.

It must be noted that because clinical trials are conducted under widely varying conditions, adverse reaction rates observed in the clinical trials of a vaccine cannot be directly compared with rates in the clinical trials of another vaccine and may not reflect the rates observed in practice.



U.S. COVID-19 Vaccine Adverse Effects - Pfizer vs Moderna

Individuals who receive the Moderna vaccine are more likely to experience post-vaccine reactions and side effects, new data from the U.S. Centers for Disease Control and Prevention (CDC) show (table).

A greater percentage of participants who received the Moderna vaccine, compared with the Pfizer-BioNTech vaccine, reported reactogenicity; this pattern was more pronounced after the second dose.

Table. Solicited Local and Systemic Reactions[a] to mRNA-Based COVID-19 Vaccines Reported 0 to 7 Days After Vaccination—Centers for Disease Control and Prevention V-safe Surveillance System, December 14, 2020, to February 28, 2021

	No. (%)					
	Dose 1			Dose 2		
Reaction	Both vaccines (N = 3 643 918)	Pfizer-BioNTech (n = 1 659 724)	Moderna (n = 1 984 194)	Both vaccines (N = 1 920 872)	Pfizer-BioNTech (n = 971 375)	Moderna (n = 949 497)
Any injection site reaction	2 550 710 (70.0)	1 085 242 (65.4)	1 465 468 (73.9)	1 443 899 (75.2)	666 635 (68.6)	777 264 (81.9)
Pain	2 472 373 (67.8)	1 055 604 (63.6)	1 416 769 (71.4)	1 389 629 (72.3)	645 917 (66.5)	743 712 (78.3)
Redness	204 097 (5.6)	56 780 (3.4)	147 317 (7.4)	240 265 (12.5)	57 956 (6.0)	182 309 (19.2)
Swelling	379 539 (10.4)	110 077 (6.6)	269 462 (13.6)	348 986 (18.2)	100 430 (10.3)	248 556 (26.2)
Itching	197 441 (5.4)	62 486 (3.8)	134 955 (6.8)	214 658 (11.2)	60 946 (6.3)	153 712 (16.2)
Any systemic reaction[a]	1 823 068 (50.0)	797 410 (48.0)	1 025 658 (51.7)	1 333 931 (69.4)	623 746 (64.2)	710 185 (74.8)
Fatigue	1 127 638 (30.9)	483 146 (29.1)	644 492 (32.5)	1 034 462 (53.9)	464 659 (47.8)	569 803 (60.0)
Headache	943 607 (25.9)	409 359 (24.7)	534 248 (26.9)	897 005 (46.7)	392 266 (40.4)	504 739 (53.2)
Myalgia	705 100 (19.4)	281 743 (17.0)	423 357 (21.3)	845 314 (44.0)	357 381 (36.8)	487 933 (51.4)
Chills	321 009 (8.8)	116 034 (7.0)	204 975 (10.3)	600 354 (31.3)	220 831 (22.7)	379 523 (40.0)
Fever	314 676 (8.6)	116 951 (7.0)	197 725 (10.0)	566 112 (29.5)	208 976 (21.5)	357 136 (37.6)
Joint pain	317 034 (8.7)	123 319 (7.4)	193 715 (9.8)	492 031 (25.6)	192 926 (19.9)	299 105 (31.5)
Nausea	275 423 (7.6)	114 087 (6.9)	161 336 (8.1)	319 248 (16.6)	127 454 (13.1)	191 794 (20.2)
Vomiting	25 425 (0.7)	9966 (0.6)	15 459 (0.8)	31 056 (1.6)	11 276 (1.2)	19 780 (2.1)
Diarrhea	189 878 (5.2)	83 016 (5.0)	106 862 (5.4)	133 877 (7.0)	60 641 (6.2)	73 236 (7.7)
Abdominal pain	111 044 (3.0)	47 096 (2.8)	63 948 (3.2)	117 494 (6.1)	48 129 (5.0)	69 365 (7.3)
Rash outside of injection site	42 409 (1.2)	17 765 (1.1)	24 644 (1.2)	32 686 (1.7)	13 132 (1.4)	19 554 (2.1)

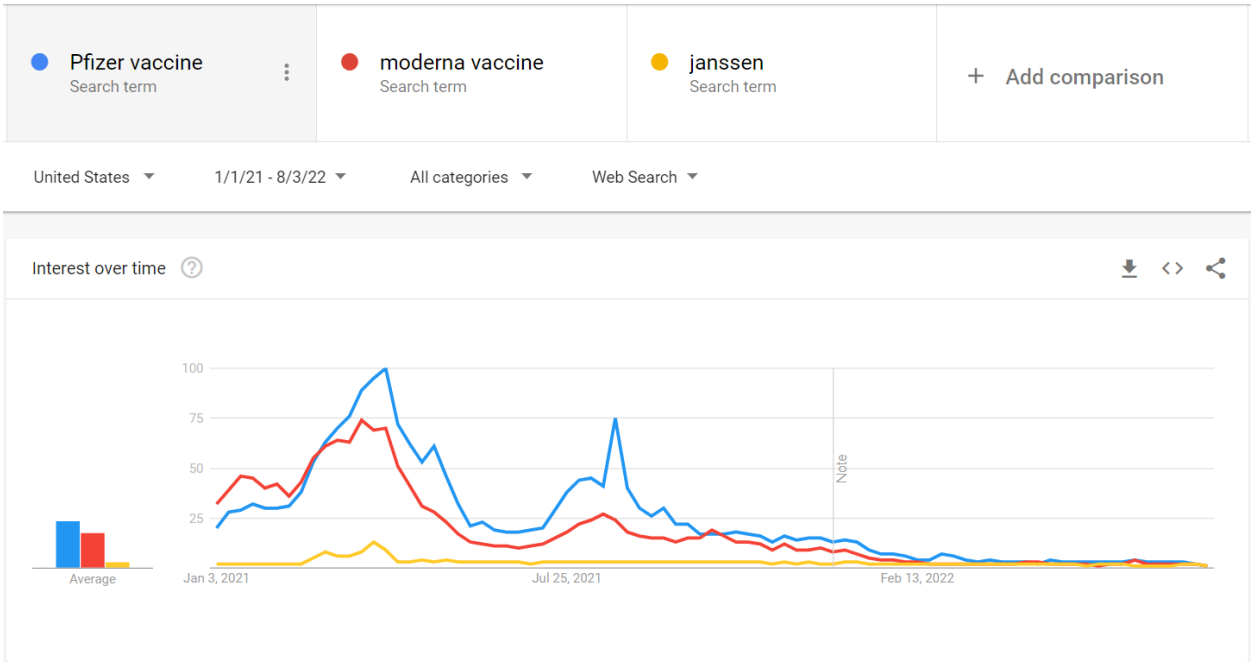
[a] Systemic reactions do not include allergic reactions or anaphylaxis.

COVID-19 Vaccine – A study by CDC

The recent study done by CDC among health health care personnel, first responders, and other essential workers aim to look at the effectiveness of Pfizer-BioNTech and Moderna mRNA vaccines in preventing Covid infections among 3,950 study participants in six states over a 13-week period from December 14, 2020 to March 13, 2021.
Results showed that following the second dose of vaccine (the recommended number of doses), risk of infection was reduced by 90 percent two or more weeks after vaccination. Following a single dose of either vaccine, the participants' risk of infection with SARS-CoV-2 was reduced by 80 percent two or more weeks after vaccination.

COVID-19 Vaccine - Interest Over time

Based on the google trends data, pfizer stood out as most searched over others and searched in most of the states in USA.



Ethical Concerns

In this study, I have used the publicly available information on coronavirus, COVID-19 vaccine, Pfizer/BioNTech and Moderna vaccines; hence, Ethical approval is not required.

Challenges and Opportunities

- New Viral variants may pose great challenges to current vaccines
- Although the protection of current vaccines against variants has declined to various degrees, they are still higher or close to the level of protection defined by the WHO of at least 50%. The vaccine is very effective against severe, critical or fatal diseases caused by Covid-19.
- COVID-19 vaccine hesitancy in the US throughout the pandemic has revealed inconsistent results.

CONCLUSION

Covid-19 vaccines can protect recipients from a Covid-19 infection by formation of antibodies and provide immunity against a Covid-19 infection. Though based on number of vaccines administered in USA, Clinical trials observation, Efficacy rate, adverse effects, google trends - it is natural for one to believe Pfizer is more effective but scientifically it is unfair to compare as they were tested in different points in time. They were tested in different group of people when there were different strains circulating in those different group of people.

Both vaccines can cause various adverse effects, but these reactions are reported to be less frequent in the Pfizer/BioNTech vaccine compared to the Moderna COVID-19 vaccine; however, the Moderna vaccine compared to the Pfizer vaccine is easier to transport and store because it is less temperature sensitive. Also please note the efficacy rates, observations studies from trails done not the actual people vaccinated as of today. Bases on all these factors, I conclude it is difficult to decide which one is better.

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