Impact of Sociodemographic Factors on COVID-19 Vaccination Rates and Infection Rates in California

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Abstract

On January 31, the first COVID-19 case was detected in California. Since then, over 4.5 million people in California have contracted the virus. California is one of the most, if not the most, diverse state in the US. The speed of the vaccine push in California and general precautions around the pandemic make the state incredibly valuable. Studying vaccination, infection, and mortality rates within sociodemographic groups (age, race, and gender) will give crucial insights into how different groups were affected by COVID-19. Data on COVID-19 vaccines, cases, and deaths from February 2021 to May 2023 were collected for analysis. The data was separated by age, race, and gender and divided by demographic. Modifications were made to the data to create several different metrics. These metrics include, percentage of a demographic that was fully vaccinated, percentage of cases represented by a certain demographic, and many more. These metrics were graphed as a function of time and compared to find discrepancies between groups. Ages 18-49 were more likely to catch the virus while ages 65+ had a far higher mortality rate than any other group. The most glaring finding between races was the incredibly low vaccination rates for American Indians/Alaska Natives in comparison. Women were more likely to catch the virus, but men were significantly more likely to die from the virus. Ideally the insights of this study can be useful in the future if a similar situation to the pandemic arises.

Introduction

In December 2019, the world as we know it changed as the COVID-19 pandemic swept across the globe, drastically altering our way of life for several years with lingering effects still prevalent today. This respiratory illness has manifested in numerous variants with differing levels of strength and transmissibility (The Johns Hopkins University, 2022). It is a notably contagious virus that has tragically claimed the lives of millions worldwide (The Johns Hopkins University, 2022; The New York Times, 2023). The origins of the pandemic trace back to Wuhan, China, with the first confirmed COVID-19 case documented on December 12, 2019 (CDC, 2023). In the United States, the initial case emerged on January 20, 2020, and in California, it was identified on January 31, 2020 (CDC, 2023; Ortiz et al., 2021). For the purpose of this project, data exclusively from California was utilized.

There are compelling reasons to focus on COVID-19 data within this state. California, if regarded as an independent nation, would rank 13th worldwide in total COVID-19 cases and 18th in total COVID-19 deaths as of October 4, 2023 (The New York Times, 2023; The New York Times, 2023). Additionally, its exceptional sociodemographic diversity makes it an invaluable source of insight into how the pandemic affected various demographics.

California was the leading state when it came to the vaccine push thanks to Governor Gavin Newsom's policies. They were the first state to require students to be vaccinated in order to return to school, leading to one of the lowest total school closure rates in the nation, despite being the most populous state (Office of Governor Gavin Newsom, 2021). California's vaccine policies and speed of vaccine distribution make it an ideal candidate to study patterns in vaccination among various demographics.

The COVID-19 vaccine itself was incredibly unique in its development and approval for public use. Vaccines are a simple and safe way to protect one from harmful diseases by building immunity to them before even coming in contact with these diseases (World Health Organization, 2021). Vaccines for the flu, mumps, hepatitis and more are required by schools for most students because they are proven to build immunity. They are typically developed using deactivated viruses or live-attenuated viruses. Typically, they take 10-15 years to develop because of the long processes for testing and approval. The fastest vaccine ever to be made prior to COVID-19 was for mumps, which took four years. Given the immediate necessity for a vaccine, the United States started "Operation Warp Speed," which attempted to create a vaccine as fast as possible (Brothers, 2020).

This program took advantage of a new vaccine technology -- messenger RNA vaccines. Messenger RNA is also known as mRNA, which is a single stranded RNA that is used in protein synthesis. This new vaccine encoded the spike protein found in the SARS-CoV-2 virus into mRNA. Since the spike proteins are foreign to the humans, the body learns how to defend against it, hence learning how to defend against the virus. This allowed for the development and approval of an effective vaccine in record time (Brothers, 2020).

Despite the health benefits and safety that comes with vaccines, many people do not support vaccination. This concept is known as vaccine hesitancy and is primarily due to an ingrained distrust in doctors and government officials. This distrust stems from historical issues and negative anecdotal experiences with the health care system.

One of the primary causes of vaccine hesitancy is the myth that vaccines cause autism. Andrew Wakefield, a physician in London, published an article in the late 1990s in which he concluded that the measles vaccine causes autism. This conclusion was based on a study in which just eight children participated. His theory was that the measles vaccine caused inflammatory lesions in the colon, which led to neurotoxic proteins in the bloodstream, and hence the brain, which caused autism. While at first glance, all eight children supported his hypothesis, the findings should not have been of much significance due to the small sample size. However, the parents of children with autism believed the findings because it gave an explanation for what was happening. This study grew out of proportion and led to a belief that vaccines are linked to autism (Davidson, 2017).

Similarly, the Tuskegee Experiment led to immense distrust in vaccines in African American and other minority communities. It began in 1932 when there was no known cure for syphilis. With the promise of free medical care, 600 African American men were unknowingly enrolled in the project, which was actually to study the full progression of the disease. The men were informed that they were being treated for "bad blood," a term used at the time to refer to various ailments. The men were given placebos despite penicillin becoming the recommended treatment 15 years into the study. No effective care was given in order to study the full progression which led to many men dying, going blind, and several other health issues from the untreated disease (Nix, 2017).

California is a great place to see the effects of a fast vaccine and vaccine hesitancy given its size and diversity. By studying vaccination rates and infection rates of COVID-19 in California, one can determine if sociodemographic factors affect vaccination and whether that has an impact on infection and mortality rates.

Methodology

COVID-19 vaccine and infection data by demographic (age, race, gender) in California from February 2021 to May 2023 was obtained. The data is from the California Health and Human Services (CHHS) Open Data Portal. For age groups, the vaccine dataset consists of the following categories: Under 5, 5-11, 12-17, 18-49, 50-64, and 65+. The infection dataset consists of the following categories: 0-17, 18-49, 50-64, and 65+. For race, the vaccine and infection datasets consist of the following categories: American Indian/Alaska Native, Asian, Black, Latino, Native Hawaiian/Pacific Islander, White, Multi-Race, and Other. For gender, the vaccine and infection datasets consist of male, female, and unknown.

The two packages needed to carry out the analysis were imported. The first package was Pandas, which is a software library used for data manipulation and analysis. It was used to handle the large amounts of data and create data frames that were easier to use. The other package was MatPlotLib, which is a plotting library for creating visualizations in Python. It was used for graphing all the data. After this, the datasets were read as a Pandas dataframe, the necessary data for that analysis was selected, the data was sorted by entry date, and lastly the data from February 2021 to May 2023 was selected. After loading and cleaning, the data was ready for analysis.

Since all the graphs are functions of time, lists were created that contained all their dates of entry as datetimes for each group within a demographic. This would serve as the x-axis for each graph. Next, lists were made that would be the y-axes of the graphs. For vaccination, these lists consisted of cumulative vaccine doses administered, proportion of the demographic that is fully vaccinated, partially vaccinated, or has at least one dose of the vaccine. For infection, the lists consisted of total cases, percent of all cases that this demographic represents, percent of all cases that this demographic represents compared to their population, total deaths, percent of all deaths that this demographic represents, and percent of all deaths that this demographic represents compared to their population.

Each of these lists would contain values that were specific to a certain group within a demographic. For example, a list may contain the cumulative vaccine doses administered to ages 18-49. Some of these lists, such as cumulative vaccine doses and total cases/deaths, were created simply by taking it from the dataset because the statistic was part of the data. Other lists, such as proportion of a certain demographic that is fully vaccinated and percent of deaths compared to their population, required extra steps to create.

To find the proportion of a demographic that is fully vaccinated, partially vaccinated, or has at least one dose of the vaccine, the data from the dataset was simply divided by that demographic’s population. The demographic population data was all retrieved using California census data. The one drawback of the census is that it only has data for under 5, 5-17, 18-64, and 65+ meaning that it doesn’t perfectly match the dataset. However, this issue was fixed by combining the values for 5-11 and 12-17, and 18-49 and 50-64 when finding these proportions. This process of finding the proportions was repeated for each and every group within each demographic category.

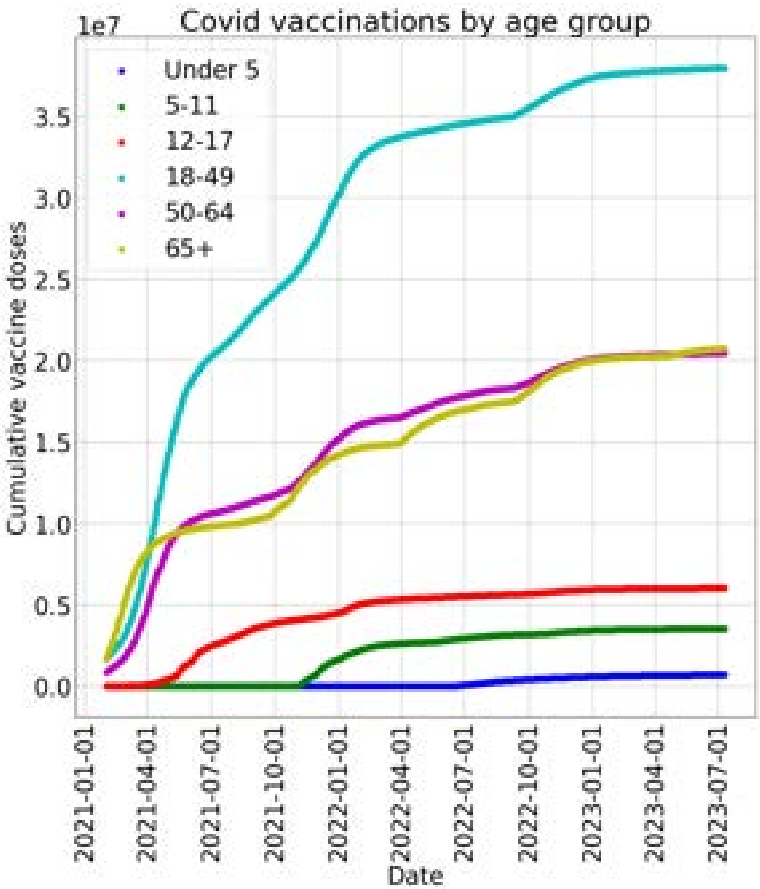
The total cases, total deaths, and percent of cases/deaths represented by a given demographic were already provided in the dataset. In order to see how the percent cases/deaths represented by a given demographic compared with that demographic's population, the actual values were compared with the demographic's population. For example, Latinos represent 15.4% of California's population. This value is called their expected value. Their expected values were subtracted from their actual values and stored to a new list. Positive numbers mean that the demographic is overrepresented, while negative numbers mean that the demographic is underrepresented.

After creating all the lists, the last step was to graph. This was done using MatPlotLib's scatter plot with the x-axis containing dates and the y-axis containing whatever data we wanted to graph (vaccine doses, total cases, etc.). Each graph was formatted to take in dates as the independent variable and also contains a legend to show what group each color represents.

Results

Ages 18-64 led in total vaccine doses received with 58,416,545 doses. Ages 65+ were next with 20,735,605 doses. Ages 5-17 followed with 9,566,279 doses and ages 5 and under were last with 713,568 doses.

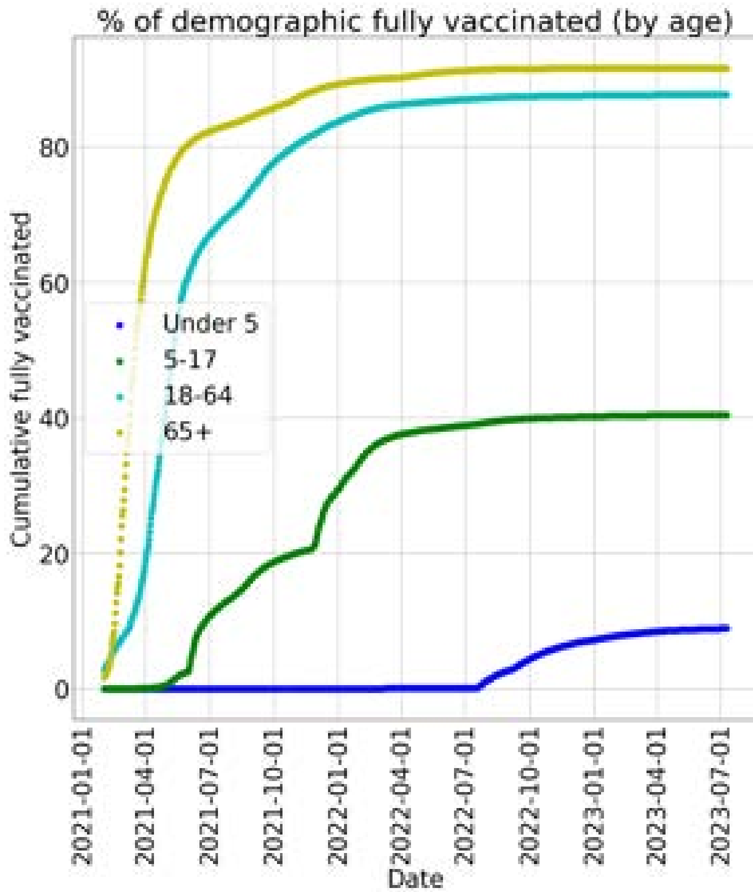
Figure 1



Note. This figure shows the cumulative number of doses of the vaccine administered to each age group over time.

Ages 65+ led in full vaccination (2+ doses) rate at 91.6%. Ages 18-64 were just behind at 87.7%. Ages 5-17 were next at 40.4%. Ages 5 and under were last at 8.9%.

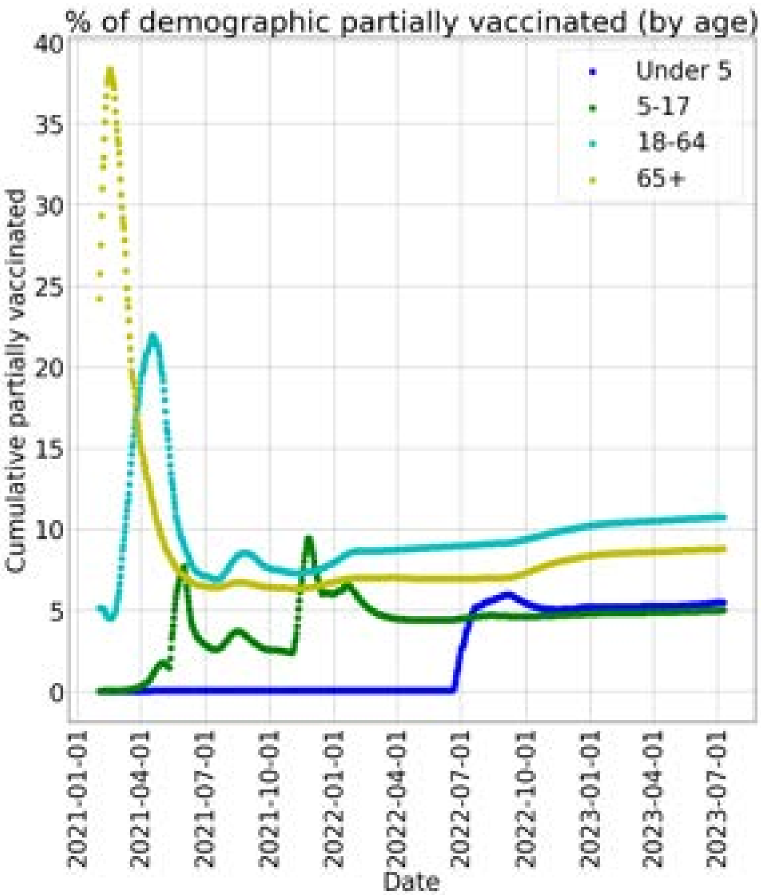
Figure 2



Note. This figure shows the total percentage of each age group that was fully vaccinated over time.

Ages 65+ led in maximum partial vaccination (1 dose) rate with a value of 38.4% and finished second with a final value of 8.8%. Ages 18-64 were second in maximum partial vaccination rate with 21.9% and finished first with a final value of 10.7%. Ages 5-17 were third in maximum partial vaccination rate with 9.4% and finished last with a final value of 5%. Ages 5 and under had the lowest peak at 6% and finished third with a value of 5.5%.

Figure 3

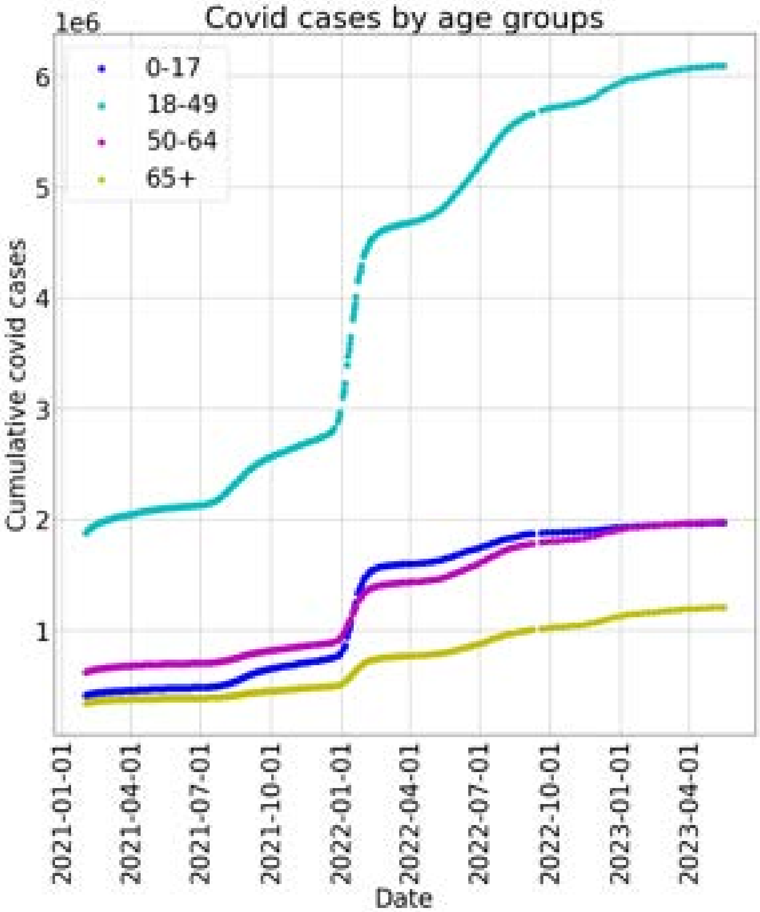


Note. This figure shows the total percentage of each age group that was partially vaccinated over time.

In all these metrics, ages 65+ increased first, followed by ages 18-64, 5-17, and 5 and under, in that order.

Ages 18-49 led in total COVID-19 cases with 6,088,447. Ages 50-64 were next with 1,979,092. Ages 0-17 were next with 1,968,275. Ages 65+ were last with 1,209,469.

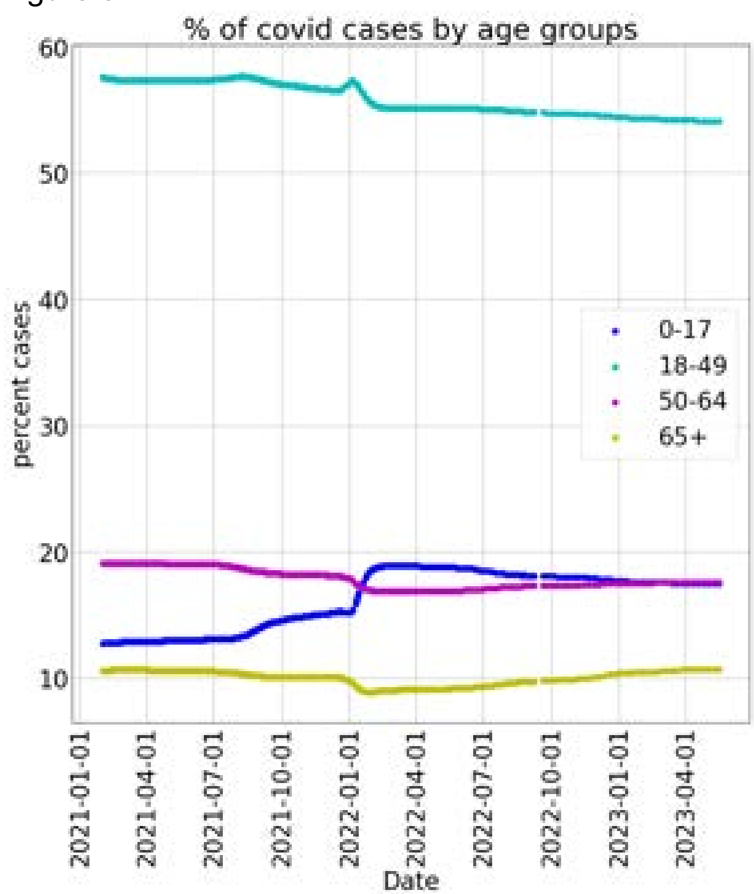
Figure 4



Note. This figure shows the cumulative number of COVID-19 cases for each age group over time.

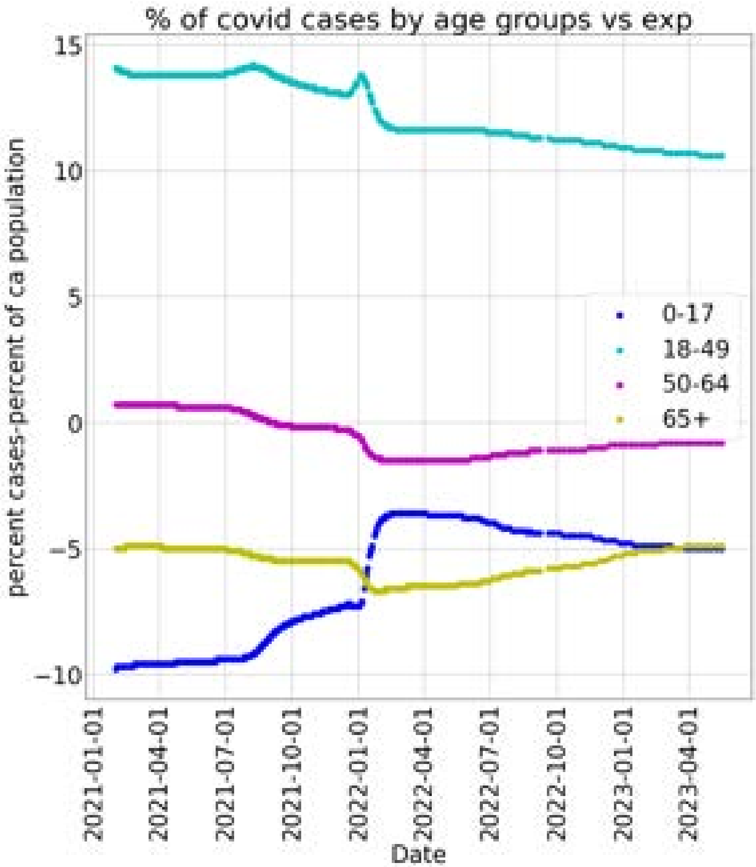
Ages 18-49 led in percentage of cases with 54.1% and also led in percentage of cases versus expected with 10.6% above. Ages 50-64 were second in percentage of cases with 17.6% and second in percentage of cases versus expected with 0.8% below. Ages 0-17 were next in percentage of cases with 17.5% and were last in percentage of cases versus expected with 5% below. Ages 65+ were last in percentage of cases with 10.7% and were third in percentage of cases versus expected 4.9% below.

Figure 5



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each age group over time.

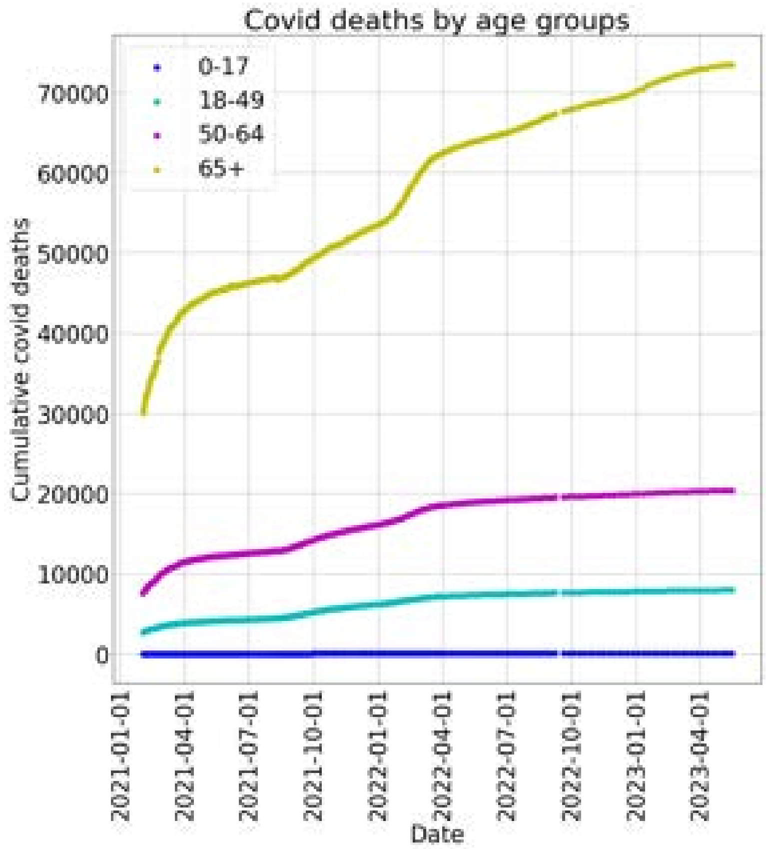
Figure 6



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each age group compared to that group's expected percentage over time.

Ages 65+ led in total deaths from COVID-19 with 73,438. They were followed by 50-64, 18-49, and 0-17, in that order, with 20,345, 7,960, and 105, respectively.

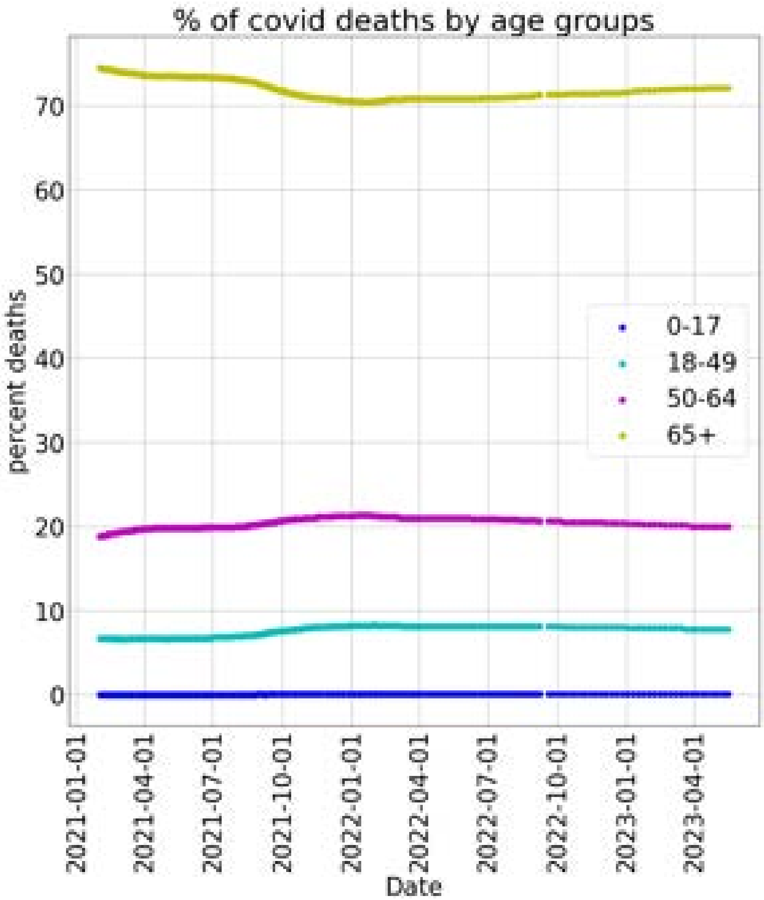
Figure 7



Note. This figure shows the cumulative number of deaths from COVID-19 for each age group over time.

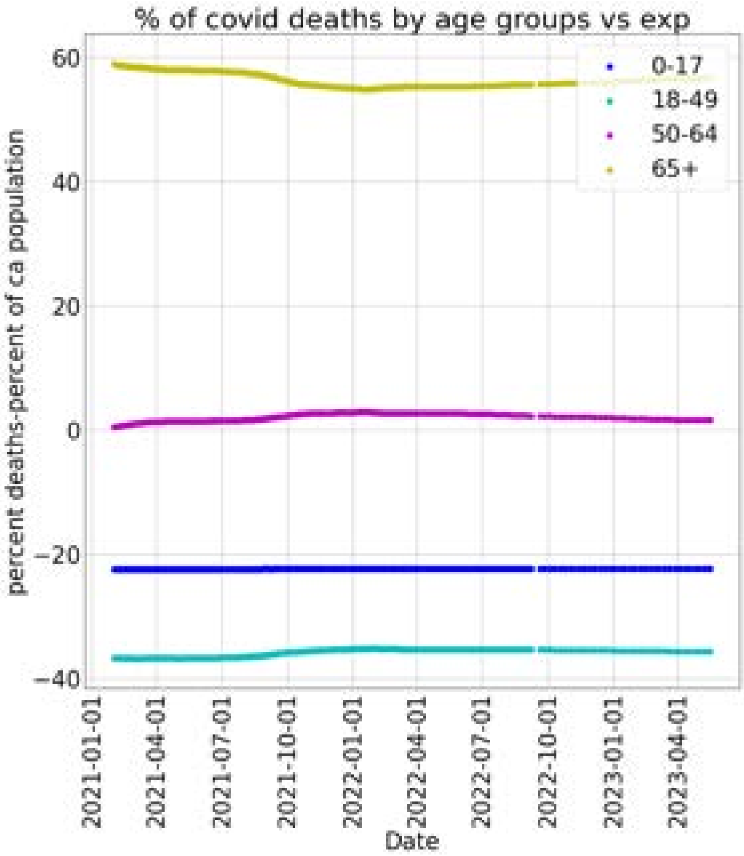
Ages 65+ led in percentage of cases 72.1% and also led in percentage of cases versus expected with 56.5% above. Ages 50-64 were second in percentage of cases with 20% and second in percentage of cases versus expected with 1.6% above. Ages 18-49 were next in percentage of cases with 7.8% and also next in percentage of cases versus expected with 35.7% below. Ages 0-17 were last in percentage of cases with 0.1% and also last in percentage of cases versus expected with 22.4% below.

Figure 8



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each age group over time.

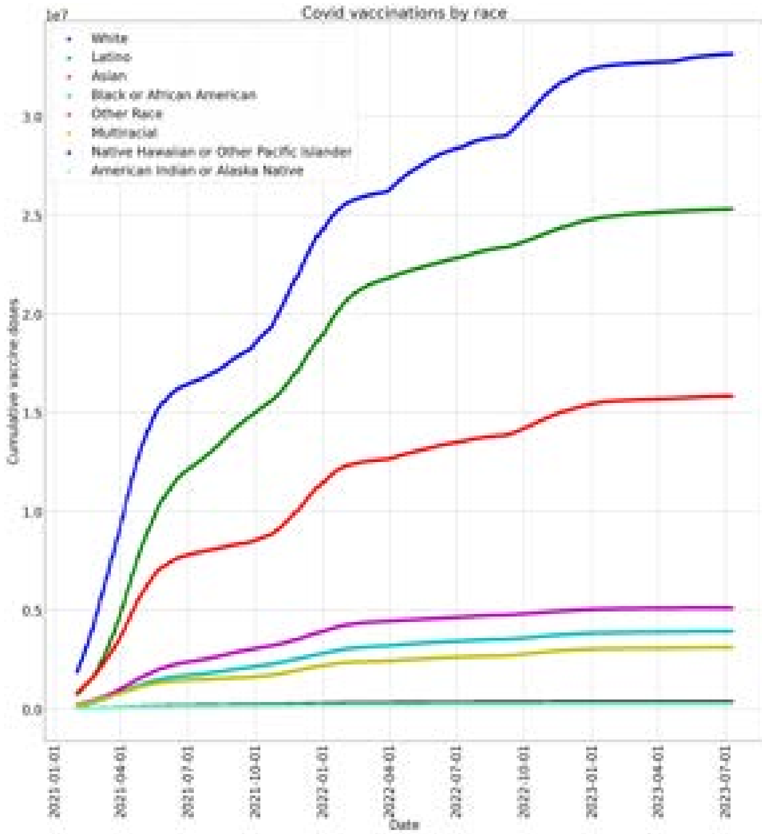
Figure 9



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each age group compared to that group’s expected percentage over time.

Whites led in total vaccine doses received with 33,160,035 doses. Latinos, Asians, Blacks, Multi-race, and Native Hawaiian/Pacific Islanders were next, in that order, with 25,309,017, 15,835,732, 3,933,715, 3,109,739, and 361,276 doses, respectively. American Indian/Alaska Natives were last with 266,061 doses.

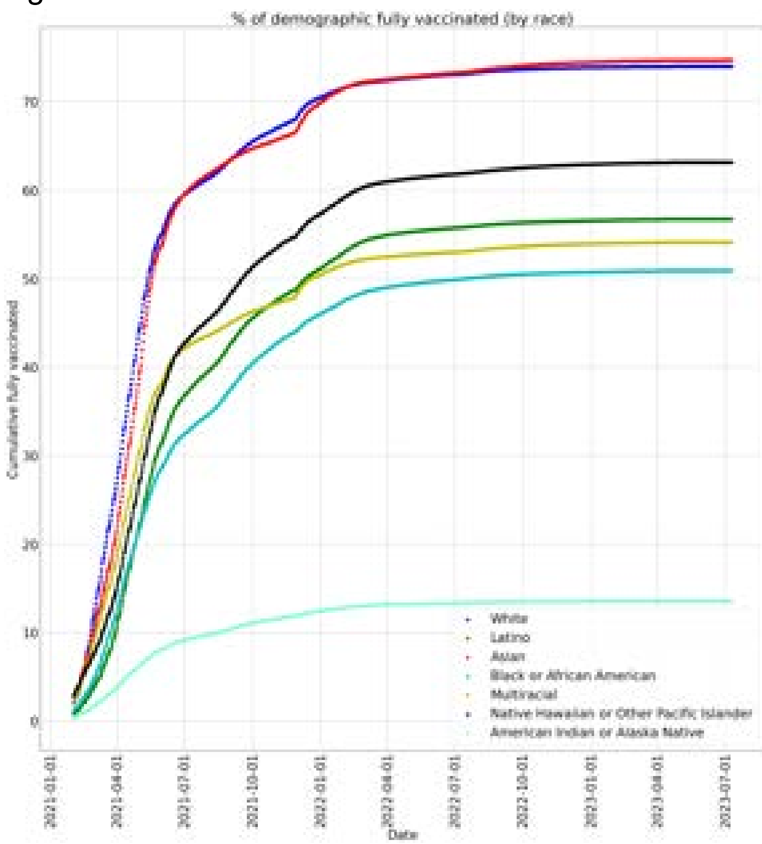
Figure 10



Note. This figure shows the cumulative number of doses of the vaccine administered to each race over time.

Asians led in full vaccination rate (2+ doses) with 74.7%. Whites, Native Hawaiian/Pacific Islanders, Latinos, Multi-race, and Blacks followed, in that order, with 74%, 63.1%, 56.7%, 54.1%, and 50.9%, respectively. American Indian/Alaska Natives were significantly below the rest with 13.6%.

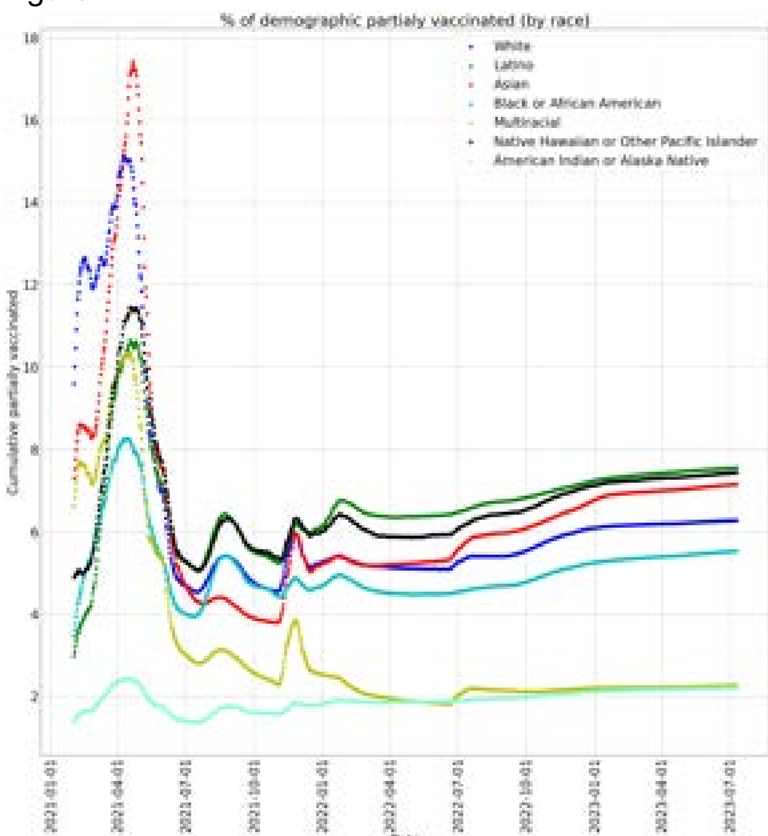
Figure 11



Note. This figure shows the total percentage of each race that was fully vaccinated over time.

Asians led in maximum partial vaccination (1 dose) rate with a value of 17.4% and finished third with a value of 7.1%. Whites were next in maximum partial vaccination rate with 15.1% and finished fourth with 6.3%. Native Hawaiian/Pacific Islanders were third in maximum partial vaccination rate with 11.4% and finished second with 7.4%. Latinos were fourth in maximum partial vaccination rate with 10.6% and finished first with 7.6%. Multi-race were fifth in maximum partial vaccination rate with 10.4% and finished sixth with 2.8%. Blacks were sixth in maximum partial vaccination rate with 8.3% and finished fifth with 5.5%. American Indian/Alaska Natives had the lowest maximum partial vaccination rate with 2.4% and also finished last with 2.2%.

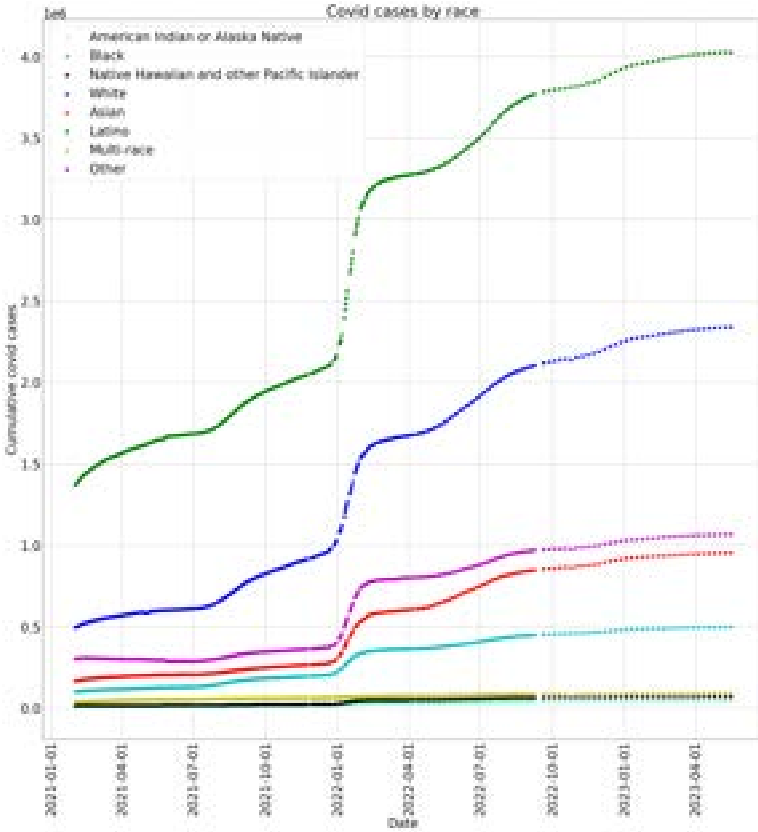
Figure 12



Note. This figure shows the total percentage of each race that was partially vaccinated over time.

Latinos led in total COVID-19 cases with 4,024,313, followed by Whites with 2,337,335, Asians with 953,199, Blacks with 497,590, Multi-race with 90,392, Native Hawaiian/Pacific Islanders with 68,563, and lastly American Indian/Alaska Natives with 41,594.

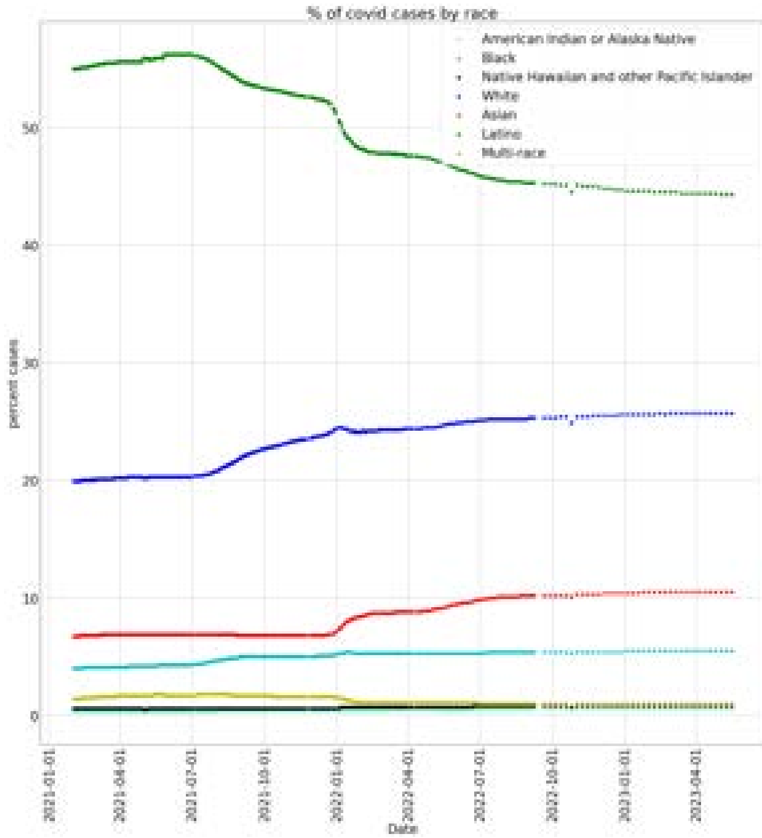
Figure 13



Note. This figure shows the cumulative number of COVID-19 cases for each race over time.

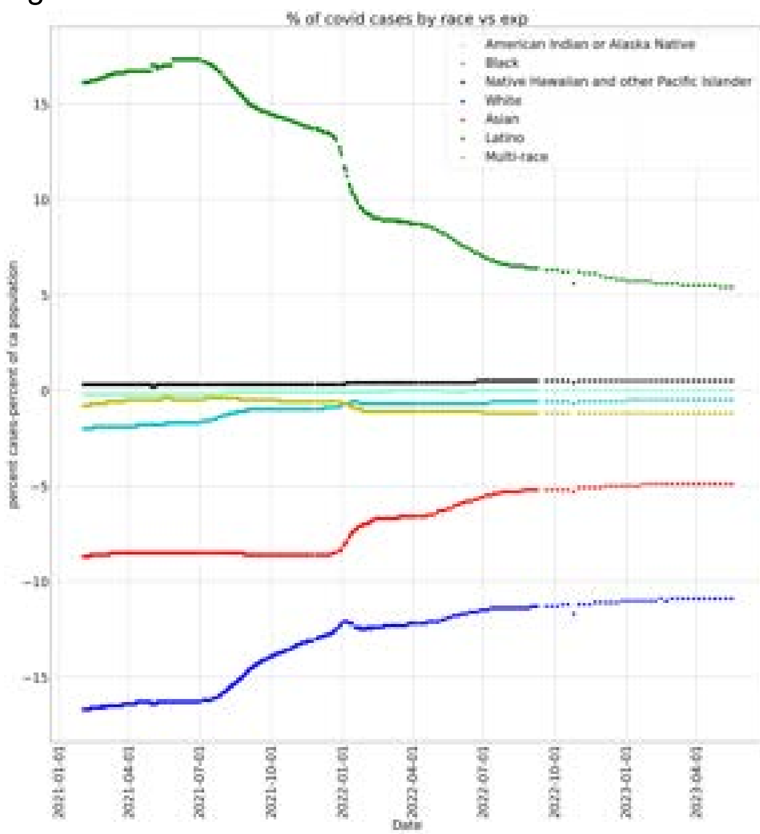
Latinos led in percentage of cases with 44.3% and also led in percentage of cases versus expected with 5.4% above. Whites were next in percentage of cases with 25.7% but were lowest in percentage of cases versus expected with 10.9% below. Asians were next in percentage of cases with 10.5% and were second last in percentage of cases versus expected with 4.9% below. Blacks were next in percentage of cases with 5.5% and were fourth in percentage of cases versus expected with 0.5% below. Multi-race were next in percentage of cases with 1% and were fifth in percentage of cases versus expected with 1.2% below. Native Hawaiian/Pacific Islanders were next in percentage of cases with 0.8% and were second in percentage of cases versus expected with 0.5% above. American Indian/Alaska Natives were last in percentage of cases with 0.5% and third in percentage of cases versus expected with no difference.

Figure 14



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each race over time.

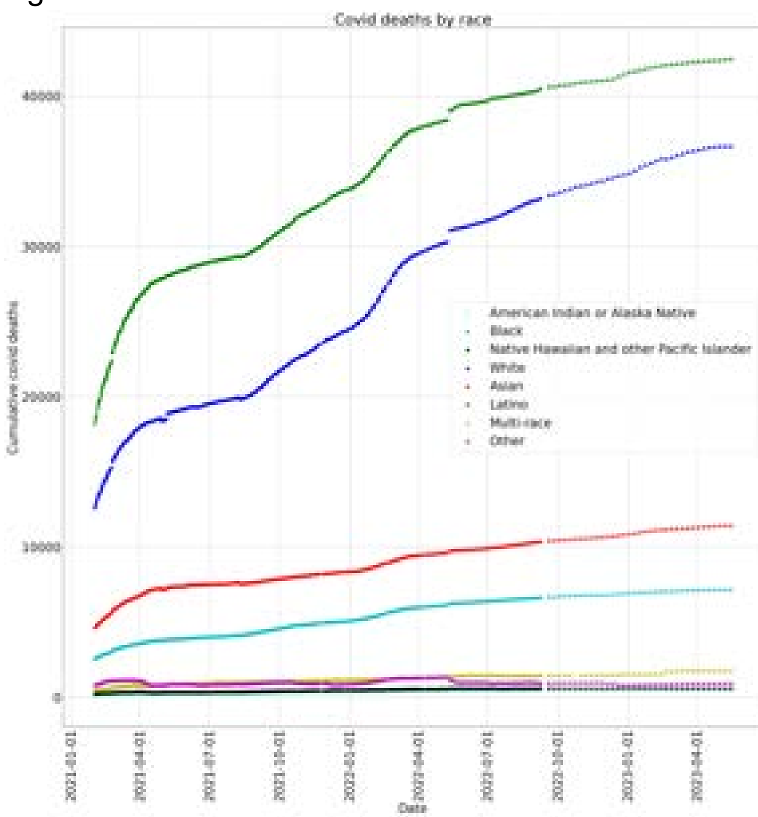
Figure 15



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each race compared to that group’s expected percentage over time.

Latinos led in total deaths from COVID-19 with 42,425. They were followed by Whites, Asians, Blacks, Multi-race, Native Hawaiian/Pacific Islander, and American Indian/Alaska Natives, in that order, with 36,635, 11,392, 7,139, 1,721, 595, and 479 deaths, respectively.

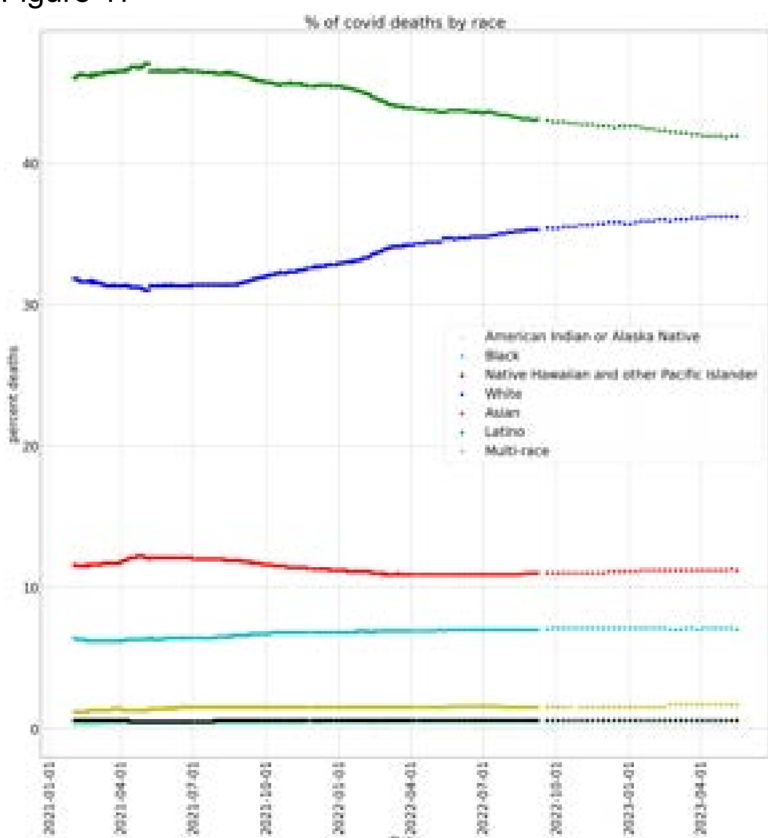
Figure 16



Note. This figure shows the cumulative number of deaths from COVID-19 for each race over time.

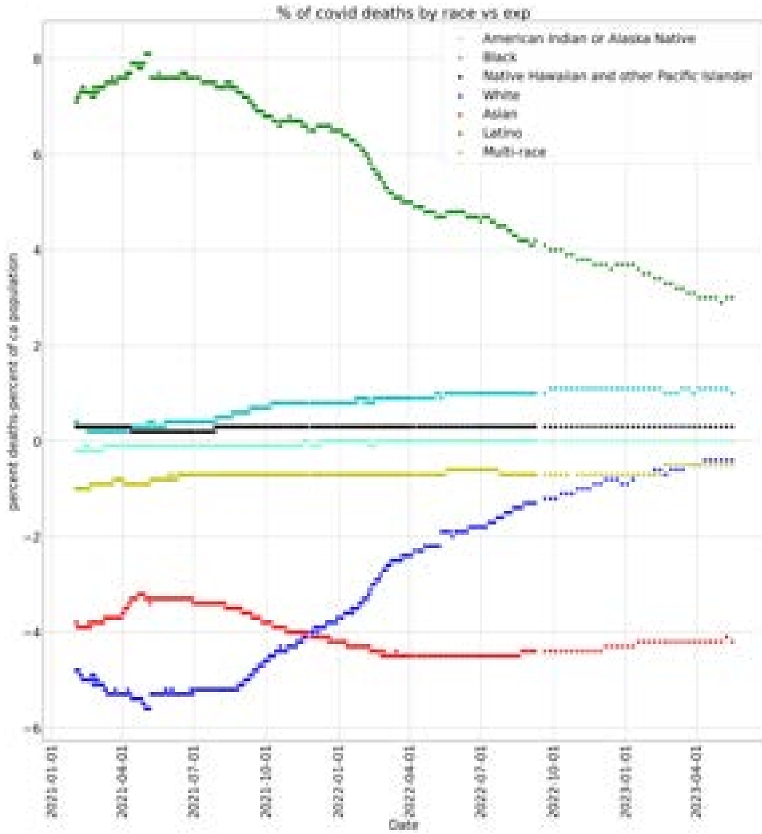
Latinos led in percentage of cases with 41.9% and led in percentage of cases versus expected with 3%. Whites were next in percentage of cases with 36.2% and started last in percentage of cases versus expected with 4.8% below but ended fifth with 0.4% below. Asians were next in percentage of cases with 11.2% and were last in percentage of cases versus expected with 4.2% below. Blacks were next in percentage of cases with 7% and were second in percentage of cases versus expected with 1% above. Multi-race were next in percentage of cases with 1.7% and were second last in percentage of cases versus expected with 0.5% below. Native Hawaiian/Pacific Islanders were next in percentage of cases with 0.6% and were third in percentage of cases versus expected with 0.3% above. American Indian/Alaska Natives were last in percentage of cases with 0.5% and were fourth in percentage of cases versus expected with no difference.

Figure 17



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each race over time.

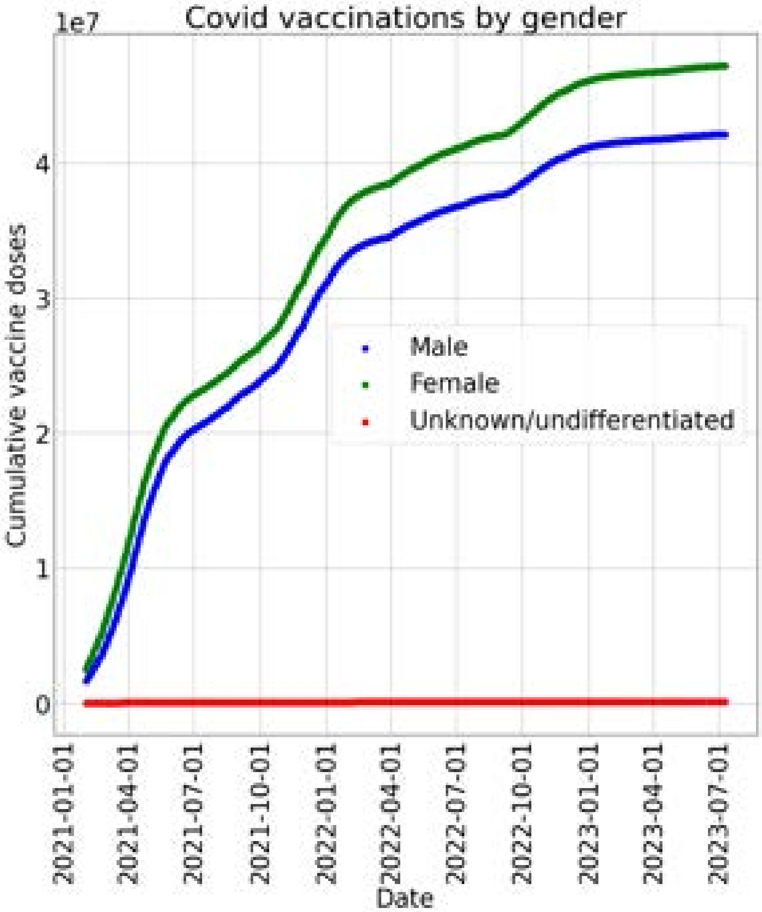
Figure 18



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each race compared to that group's expected percentage over time.

Females led in total vaccine doses received with 47,213,588 doses. Males were slightly below with 42,139,158 doses and Unknown/Undifferentiated were last with 83,022 doses.

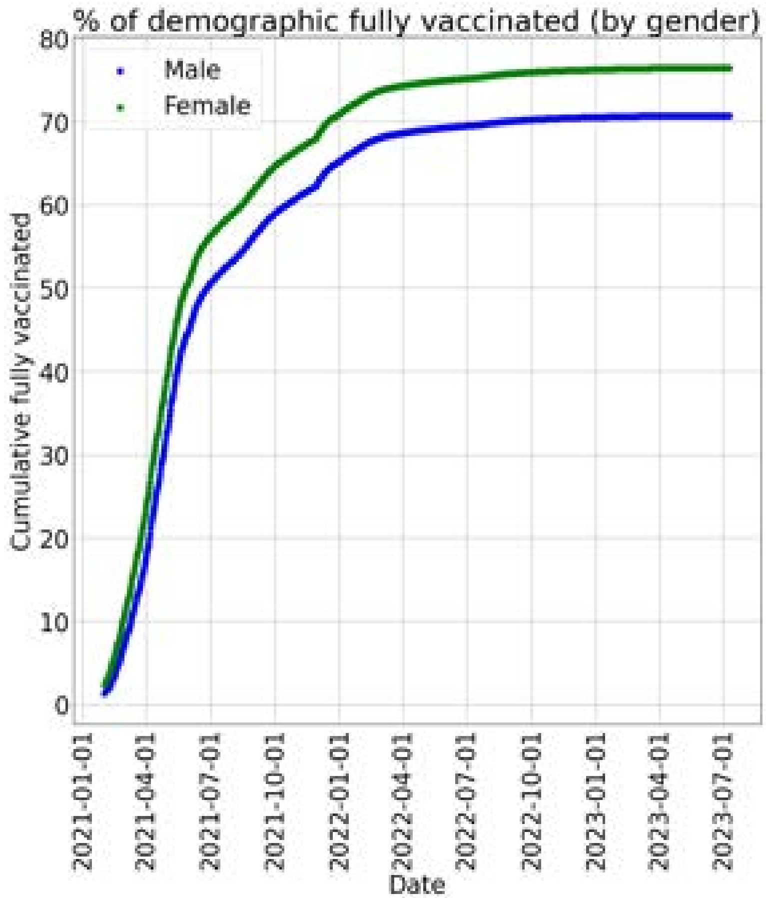
Figure 19



Note. This figure shows the cumulative number of doses of the vaccine administered to each gender over time.

Females also led in full vaccination (2+ doses) rate at 76.4% while males were just behind at 70.7%.

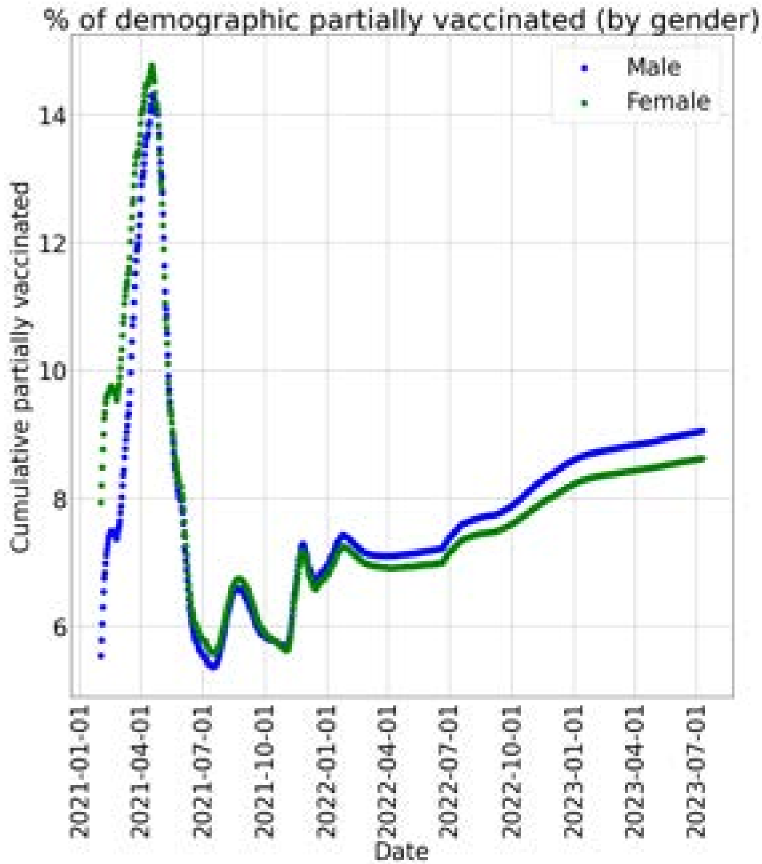
Figure 20



Note. This figure shows the total percentage of each gender that was fully vaccinated over time.

Females also led in maximum partial vaccination (1 dose) rate with 14.8% and finished last with 8.6%. Males were just behind in maximum partial vaccination rate with 14.3% and finished first with 9.1%.

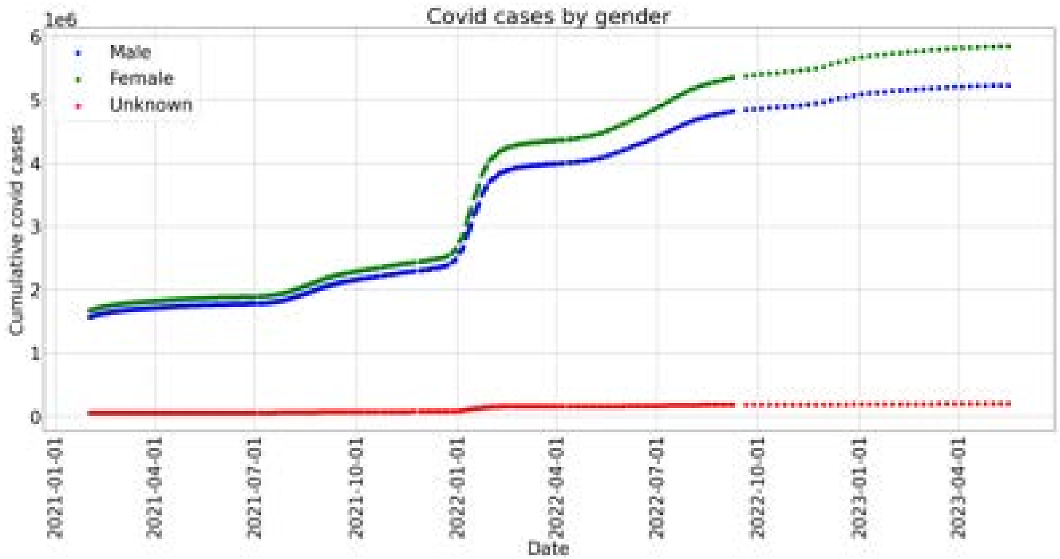
Figure 21



Note. This figure shows the total percentage of each gender that was partially vaccinated over time.

Females led in total COVID-19 cases with 5,840,492 with males right behind with 5,220,656 and Unknown/undifferentiated in last with 190,846.

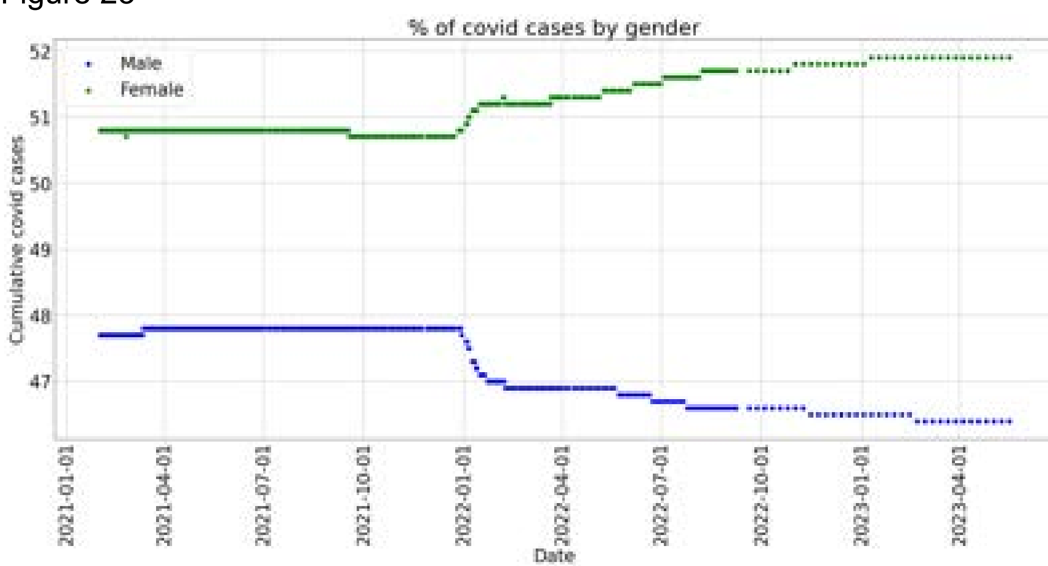
Figure 22



Note. This figure shows the cumulative number of COVID-19 cases for each gender over time.

Females led in percentage of cases with 51.9% while males were behind with 46.4%.

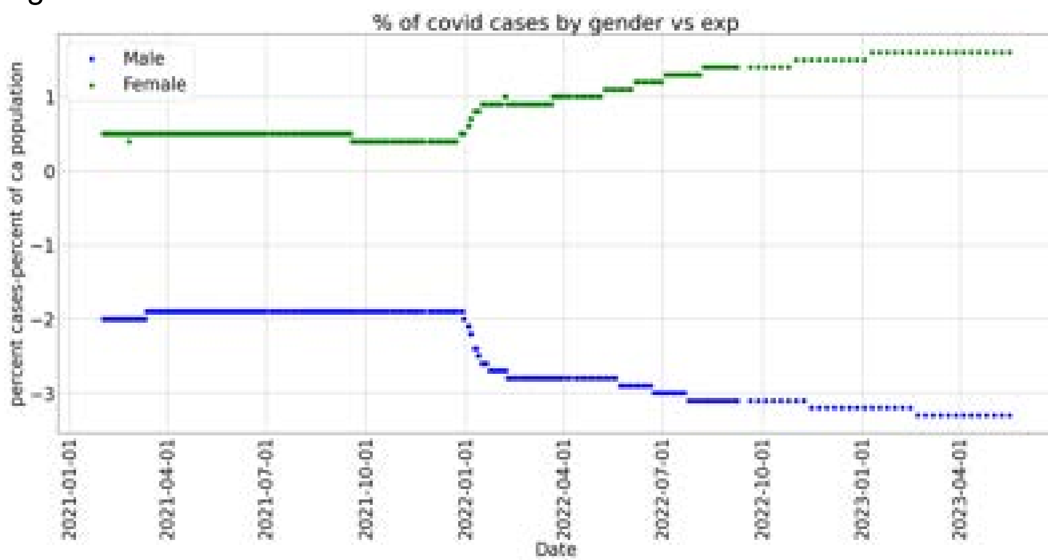
Figure 23



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each gender over time.

Females also led in percentage of cases versus expected. They started at 0.5% above expected. Suddenly in January 2022, that number started to increase, ending with 1.6% above. Similarly, males started at 2% below expected until January 2022. They then decreased, finally finishing with 3.3% below expected.

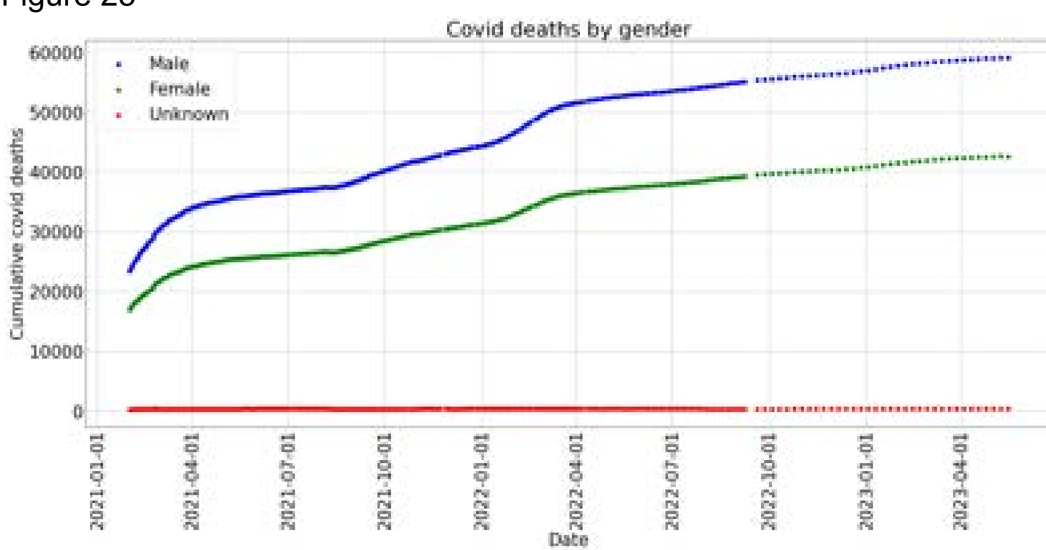
Figure 24



Note. This figure shows the percentage of COVID-19 cases at a given time represented by each gender compared to that group's expected percentage over time.

Unlike vaccination and cases, males led in total deaths from COVID-19 with 59,003. Females were behind with 42,538 deaths and Unknown/Undifferentiated were last with 313.

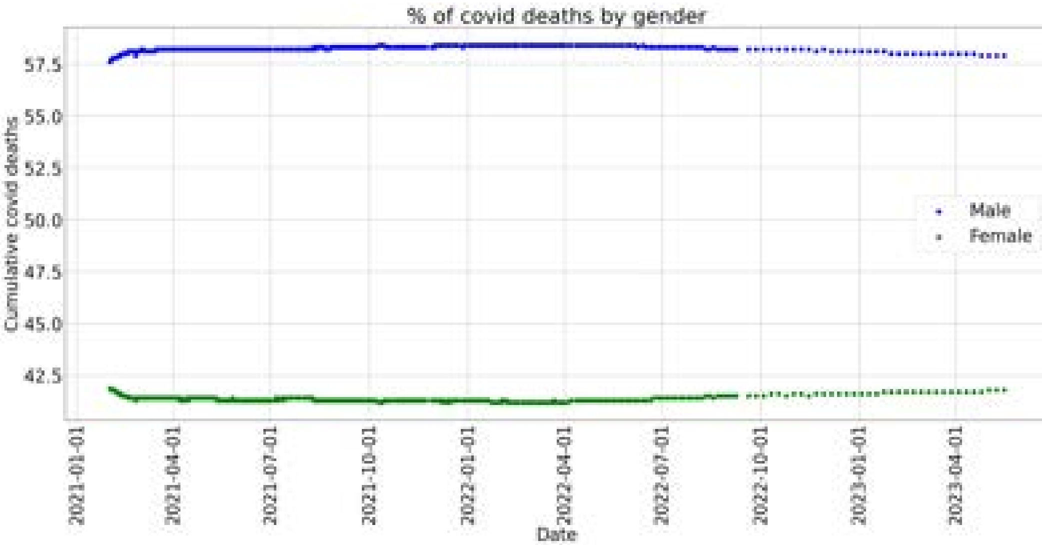
Figure 25



Note. This figure shows the cumulative number of deaths from COVID-19 for each gender over time.

Males also led in percentage of deaths with 57.9% while females were behind with 41.8%.

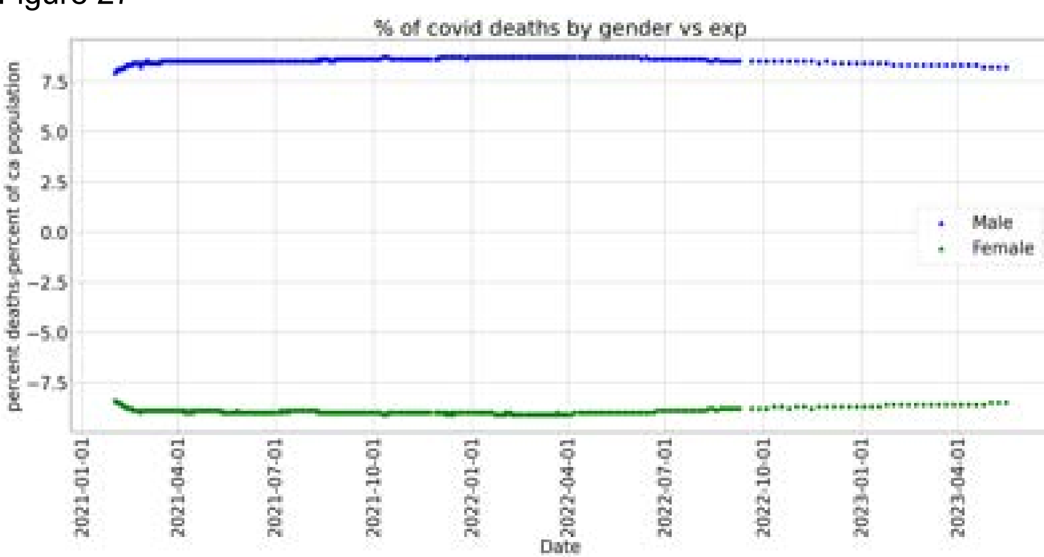
Figure 26



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each gender over time.

Males also led in percentage of deaths versus expected 8.2% above expected. Females were nearly the opposite with 8.5% below expected. These values were fairly consistent during the study period.

Figure 27



Note. This figure shows the percentage of deaths from COVID-19 at a given time represented by each gender compared to that group's expected percentage over time.

Discussion

This project seeks to find any interesting patterns or discrepancies in the results that should be studied and discussed.

By looking at all cases, it is clear that there is no correlation between vaccination and number of COVID-19 cases. In context, there is no evidence that supports the claim that getting vaccinated prevents one from getting infected. Early in the vaccine distribution, there was a misconception that getting vaccinated would prevent infection. In an article from Johns Hopkins University & Medicine, they state that they are “still learning whether or not the current COVID-19 vaccines prevent transmission of SARS-CoV-2” (Johns Hopkins University & Medicine, 2023). A later article from Johns Hopkins Medicine states that the vaccine “helps protect the person who receives it from serious illness, hospitalization, and death,” (Johns Hopkins Medicine, 2022). The data supports the idea that vaccines don’t reduce the chance of contracting the virus, but simply decrease the severity of illness.

Ages 18-49 were overrepresented in cases which is likely due to their lifestyle. Compared to the other age groups, ages 18-49 are mostly likely to go outside and spend time in large groups. These events and interactions are where the virus spreads at the greatest rate, leading to more cases for this age group.

When it comes to deaths from COVID-19, it is clear that ages 65+ lead in numbers of deaths, percentage of deaths, and percentage of deaths over expected. The percentage of deaths over expected is especially significant because they are overrepresented by a significant margin of 60%. Unlike ages 18-49, ages 65+ do not live a lifestyle that puts them in the most danger. They are not nearly as likely to contract the virus, yet they die more than any other group by a large margin.

Given that COVID-19 targets the respiratory system, a strong respiratory system and good cardiovascular functionality are essential to being able to survive the infection. Cardiovascular functionality deteriorates as one gets older, leading to a greater risk of cardiovascular disease (Rodgers et al., 2019). This weakness that comes with age is a likely explanation for the drastic overrepresentation of ages 65+ in deaths from COVID-19. It also explains the underrepresentation of ages 0-49 in deaths. The respiratory system gets stronger from birth until they mature at about 20-25 years old. Beyond age 35, the function of the lungs and other parts of the respiratory system begin to decline. The immune system also weakens with age, leaving people more vulnerable to respiratory infections (American Lung Association, 2018).

The data shows the Whites, Latinos, and Asians led in total vaccine doses administered while Native Hawaiian/Pacific Islanders and American Indian/Alaska Natives were at the bottom. When looking at the proportion of a demographic that is fully vaccinated, it is clear that Whites and Asians were most likely to get vaccines at roughly 75 percent. Latinos, Multiracial, and Blacks were between 50 and 60 percent. However, American Indian/Alaska Natives were significantly lower at just under 15 percent being fully vaccinated.

These numbers are a result of vaccine hesitancy. For Blacks, their distrust stems from historical injustices such as the Tuskegee Syphilis Study. However, the issue still exists to this day as many Black people are unhappy with the current healthcare system. A study from 2020 shows that Black participants had less trust in medical professionals and had significantly less positive experiences in the healthcare system than White participants. While a negative history has an impact on the lack of trust Black people have, it is very important to realize that inequality and injustice this group exists currently and actions need to be taken to fix it (Ober, 2022).

When vaccine rollout began, the hesitancy among vulnerable communities, specifically Hispanic people, became clear. Experts on the topic and people in these communities believe that skepticism of vaccination is rooted in unethical medical practices that targeted minorities. Unwanted sterilizations were given to minority women all over the country. Women who reported their side effects were left unheard and called unreliable. Historical events such as this left many minorities, especially Blacks, Latinos, and American Indians, scared and wondering if they can ever trust vaccination (Hassanein, 2021).

For American Indians/Alaska Natives, there are historical issues yet again. Tribal communities feel a cultural mistrust that has been piling on for a long time due to historical trauma that leads to reluctance among Natives. There are also structural inequalities and health disparities for American Indians and Alaska Native caused by decades of underfunding of tribal health care systems by the federal government. These problems were highlighted by the pandemic. There were also logistic concerns as well that made distribution of a vaccine very difficult. Tribes are located in remote areas that lack reliable transportation. They also do not have the ability to store the vaccines in a refrigerator for multiple weeks. Several tribal economies have suffered greatly from the virus, making a potential recovery extremely difficult (Cannon, 2020).

Despite these issues that affected vaccination among Latinos, Blacks, and American Indian/Alaska Natives, only Latinos are overrepresented in COVID-19 cases. Similarly, Latinos are overrepresented in deaths from COVID-19. Blacks and American Indian/Alaska Natives are slightly overrepresented in this category, but strangely they are still not impacted as significantly as Latinos.

With regards to gender, women are higher in total vaccine doses administered and full vaccination percentage. Women are also slightly overrepresented in the number of cases and percentage of cases versus expected. Despite this, men have more total deaths from COVID-19 and also have a percentage of death versus expected of about 7.5% over expected. Given that women have more total cases, it is expected that they would also have more deaths. However, unexpectedly, men have more deaths. There are several likely reasons for these discrepancies.

A study about the risk of cardiovascular disease states that the incidence of cardiovascular disease is slightly higher in females over the age of 60. This discrepancy is attributed to the sex differences such as sex hormones and their associated receptors (Rodgers et al., 2019). This could possibly explain the overrepresentation of women in the number of cases.

Another potential reason can be found in life expectancy. Women have had a higher life expectancy than men for decades now. The disparity in life expectancy between men and women is at the largest gap since 1996 at 5.9 years in 2021 (CDC, 2023). While there is no direct scientific explanation for this gap, there are a few theories.

One key factor is the fact that men tend to take bigger risks in their lives. The part of the brain, the frontal lobe, that deals with judgment and decision making develops slower in boys and young men. This leads to men making detrimental lifestyle choices, such as smoking and drinking in higher percentages than women on average. Men tend to avoid doctors. Whether that is regular health screenings, or reporting symptoms when they have an issue, men simply don't report it the way that women do. Men also are 50% more likely to die of heart disease (Shmerling, 2016). This is due to the fact that men have lower estrogen levels than women. It can also be a result of untreated medical risks like high blood pressure which connect back to the fact that men avoid doctors and don't report their issues as much as they should (Shmerling, 2016). It is obvious that these reasons are not comprehensive and further research is needed to explain these discrepancies.

One obvious limitation of the study is that there is a portion of the data that is unclassified, meaning that there are people who are unaccounted for. Given that there are no population values for this group, the study is not completely comprehensive. In addition, the data for cases and deaths from the virus is not specific to people who are vaccinated. If such a dataset existed, this would have been useful to do a deeper analysis on each group. One way to expand the study would be to repeat the analysis in a right-leaning state. California is a very democratic state where the vaccine push was a priority. It would be insightful to see what discrepancies are revealed if a republican state was studied.

In this study, data about COVID-19 vaccination, infection, and mortality was analyzed by several sociodemographic factors (age, race, and gender) in order to reveal any discrepancies in the data relating to the aforementioned factors. The analysis revealed discrepancies within each factor. Ages 18-49 were more likely to catch the virus while ages 65+ had a far higher mortality rate than any other group. The most glaring finding between races was the incredibly low vaccination rates for American Indians/Alaska Natives in comparison. Women were more likely to catch the virus, but men were significantly more likely to die from the virus.

There are several steps that need to be taken immediately to ensure that such issues do not occur again. One step is to improve scientific literacy. A greater understanding of science will allow people to make more informed decisions, and truly understand the situation at hand. Additionally, the vaccine push needs to be more inclusive and informative. Groups that have difficulty getting the vaccine should receive extra support to ensure that they can get the vaccine just as everyone else does. It is also important for people to understand what the vaccine does and why they should receive it. Ideally, this study can be useful in the future if a similar situation to the COVID-19 pandemic arises.

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