

Factors Which Contributed to COVID-19 Vaccine Hesitancy in the USA

Nicole Robson¹ and Renata Ivanek Miojevic[#]

¹Fountain Valley High School, Fountain Valley, CA, USA

[#]Advisor

ABSTRACT

The COVID-19 pandemic took the lives of millions worldwide. To help control the infection spread, COVID-19 vaccines were created. However, many were reluctant to receive these vaccinations. The objective of this study was to evaluate factors that influenced someone in the United States of America (USA) to get vaccinated. Towards this end, we evaluated data collected from April to July of 2021 (3-4 months after the vaccine's deployment) as part of the publicly available US Census's Household Pulse Survey. In comparison to other state-to-state research, our study intends to give an outlook on the USA as a whole. Statistical analysis was used to compare the odds ratios (ORs) describing associations between the vaccination status and the various factors, and the associated 95% confidence intervals. Findings indicated that those who received the COVID-19 vaccination were more likely to be non-Hispanic, male, and those who had higher levels of formal education, had children not enrolled in a public school, and had higher household income. Also, we evaluated the association between vaccination status and working in the white (healthcare and social services), pink (education), or blue (such as, agriculture, manufacturing, and public transit) collar essential job sectors. The results showed that participants employed in the blue collar sectors were less likely to get the vaccine compared to those in pink and white. Overall, the findings of this study will help determine which demographics of people are less likely to receive the COVID-19 vaccination to possibly help more effectively target vaccinations in the future.

Introduction

The COVID-19 vaccines are used to provide acquired immunity against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19) [1]. These vaccines help the body develop immunity to the virus in order to protect it from having severe symptoms in the future. Research regarding the COVID-19 vaccine and its acceptance amongst different demographics of people is an important topic to discuss as an accepted way to create a safer environment in response to the COVID-19 pandemic is through large rates of vaccination among as many communities as possible. As new variants of the virus and new variations of the vaccine emerge, it is important to understand what makes a person hesitant to accept the vaccine, and to communicate what is known and unknown about the vaccine to possibly prevent some of the hesitancy amongst various groups of people. As of September 12, 2022, there have been 6,515,928 deaths worldwide from COVID-19. [2]. Vaccines have been employed as a key way to reduce the number of deaths worldwide. In the United States of America (USA), there are a number of approved vaccines, such as Pfizer-BioNTech, Moderna, and Johnson & Johnson's Janssen, but their implementation into the country was difficult due to a hesitancy amongst some individuals to receive the vaccine [3]. The World Health Organization defines vaccine hesitancy as "the reluctance or refusal to vaccinate despite the availability of vaccines – threatens to reverse progress made in tackling vaccine-preventable diseases" [4]. Vaccine hesitancy is an issue that may be due to different factors present in a person's life.

The objective of this study was to determine the factors that influenced whether or not someone in the USA chose to get the COVID-19 vaccination during the early period of vaccine availability and whether industry sectors in the United States (US) differed regarding the percentage of vaccinated people employed in those sectors. In this study, we will take a look at a few different demographics of people to determine if there are any certain groups that needed to be more effectively deployed the vaccine. For this study, we chose to look at different factors including whether or not a person had previously been diagnosed with COVID-19, gender, level of education, yearly household income, number of children enrolled in public school, and whether or not a person identified as Hispanic. Also, a separate analysis was done comparing different areas of work and how many people in white, blue, and pink collar essential jobs were vaccinated or unvaccinated. White collar jobs are those that work in healthcare and social services, while pink collar jobs are those working in the education field. Blue collar jobs are all the rest of the essential jobs (first response, deathcare, correctional facility, food and beverage store, agriculture, forestry, fishing, hunting, food and non-food manufacturing, public transit, and US postal service). Our hypotheses are that people who took the COVID-19 vaccine are more likely to have higher levels of education and income, not have their children enrolled in public school, are women, have had COVID-19 before, and are not Hispanic. Also, we hypothesized that in early 2021, the COVID-19 vaccination amongst those working in the white collar job sector was more prevalent than among those working in the pink and blue collar job sectors.

Materials and Methods

Survey Instrument

For this study, the US Census's Household Pulse Survey (HPS) was used. This survey is 20 minutes long, and is used to be able to see the impact that COVID-19 is having on households in America [5]. The HPS data is different from other surveys conducted because it is meant for more time-sensitive material, like the previously ongoing pandemic. As a consequence of its rapid deployment, it has been acknowledged that the data may be slightly below average statistical quality standards [6]. The survey is administered via the Qualtrics survey platform (<https://www.qualtrics.com/>). The participants are asked a variety of questions ranging from their age and gender to specifics about their household (i.e., healthcare, number of children, etc.) to get a better idea of what different areas of life were being affected through the COVID-19 pandemic. This survey has been administered in phases weekly or bi-weekly since April 23, 2020. The data used in the current study is from Phase 3.1, and a survey that was administered from April 14th - July 5th of 2021. Participants were contacted via email or text message if they were chosen to participate [6]. The process of choosing the participants was randomized by household address. The HPS data was approved by the Office of Management and Budget, The White House, which serves the President of the United States, through an emergency clearance as an experimental project. Then a regular clearance was granted from the same office at a later date [7].

The HPS dataset was chosen because of its easily accessible (open access) information and the wide range of questions that participants were asked. For the purpose of this study, we extracted questions on vaccination status, whether they contracted the virus or not, gender, education status, number of kids enrolled in public school, household income, whether or not a person identifies as Hispanic, and the industry sector where the survey participant is employed.

Data Editing

Responses to questions of interest from participants who had seen a question but the category was not selected

(denoted with number -99 in the survey dataset) or the responses were missing/did not record (denoted with number-88), were marked as “not available” (NA). Participants with the NA response to the vaccination status question were removed from the dataset. Participants with the NA response to any of the other questions extracted for analysis were excluded from analysis of that specific question. Vaccination status gave an option of either “yes” or “no”. Gender was categorized as male or female. Education level, number of children, and income were all given as numerical values, but for the purpose of this study we needed to have them converted into binary variables (i.e., in two groupings). So, for education, “yes” was recorded as those who had obtained at least “some college” or above, while “no” was everything below that level of education. Number of children was 1 and above being “yes”, and everything below that (i.e., 0 children) recorded as “no”; this was to separate the people who had their children enrolled in public school from those who did not. For household income, the category \$50,000- \$74,999 and above was recorded as “yes”, while everything below that category was “no”. This separation was done by identifying the approximate middle category represented as 3 levels below and 4 above the middle. Finally, Hispanic was recorded as either “yes” or “no” depending on whether or not the participant identified as Hispanic. We also extracted information about the industry sector by separating the different industry sectors based on the primary type of employees in a sector classified as white, blue and pink collar essential jobs. Namely, the blue collar jobs sector consisted of first response, agriculture/forestry/fishing/hunting, correctional facility, non-food manufacturing facilities, food manufacturing facilities, food and beverage stores, and those working for the U.S. postal service.

Pink collar job sectors were K-12 schools, other schools/instruction, and preschool or daycare, leaving healthcare and social services as white collar job sectors.

Table 1. Wording of questions and number of responses in the US Census’s Household Pulse Survey extracted for use in this study, with question short names for easy reference.

Survey “Question” [short name] <i>Response Level</i>	Response Level Notation	Number	%
“Have you received the COVID-19 Vaccination?” [vac]			
1	Yes	54359	78.9%
2	No	14162	20.6%
-99	Question seen but not selected	392	0.57%
-88	Missing/Did not Report	0	0%
“Has a doctor or other health care provider ever told you that you have COVID-19?” [hadcovid]			
1	Yes	7686	11.2%
2	No	60454	87.7%
3	Not Sure	430	0.6%

-99	Question seen but not selected	343	0.4%
-88	Missing/Did not Report	0	0%
“Are you male or female” [gender]			
1	Male	27980	40.6%
2	Female	40933	59.4%
“What is the highest degree or level of school you have completed?” [educ]			
1	Less than high school	439	0.6%
2	Some high school	1009	1.5%

3	High school graduate or equivalent (for example GED)	7751	11.2%
4	Some college, but degree not received or in progress	14444	21%
5	Associate’s degree (for example AA, AS)	7235	10.5%
6	Bachelor’s degree (for example BA, BS, AB)	20010	29%
7	Graduate’s Degree (for example master’s, professional, doctorate)	18025	26.2%
“During the school year that started in Fall of 2020, how many children in this household were enrolled in Kindergarten through 12th grade or grade equivalent?” [kids]			
0-20	Number enrolled in public school ¹	10923	15.9%
-99	Question seen, but category not selected	6449	9.3%

-88	Missing/ did not report	51541	74.8%
“In 2019, what was your total household income before taxes?” [income]			
1	Less than \$25,000	4941	7.2%
2	\$24,000- \$34,999	4111	6%
3	\$35,000- \$49,999	5097	7.4%
4	\$50,000- \$74,999	8544	12.4%
5	\$75,000- \$99,999	7288	10.6%
6	\$100,000- \$149,999	9511	13.8%
7	\$150,000- \$199,999	4862	7.1%

8	\$200,000 and above	5919	8.6%
-99	Question seen but category not selected	1951	2.8%
-88	Missing/ did not report	16689	24.2%
“Are you of Hispanic, Latino, or Spanish Origin?” [hispanic]			
1	No, not of Hispanic, Latino, or Spanish origin	62311	90.4%
2	Yes, of Hispanic, Latino, or Spanish Origin	6602	9.6%
“Since January 1, 2021, which best describes the primary location/ setting where you worked or volunteered outside your home?” [setting]			
1	Healthcare	5531	8.0%
2	Social Service	1500	2.2%
3	Preschool or Daycare	367	0.5%
4	K-12 School	2790	4.0%
5	Other Schools or Instructional Facilities	1256	1.8%

6	First Response	487	0.7%
7	Death Care	67	0.1%
8	Correctional Facility	113	1.6%
9	Food and Beverage Store	1443	20.9%
10	Agriculture, Forestry, Fishing, or Hunting	538	0.8%
11	Food Manufacturing Facility	261	0.4%
12	Non- Food Manufacturing Facility	1054	1.5%

13	Public Transit	202	0.3%
14	United States Postal Service	130	1.9%
15	Other Jobs Deemed “essential” During the COVID-19 Pandemic	6516	9.5%
16	None of the Above ²	8024	11.6%
-99	Question Seen but Category Not Selected	77	0.1%
-88	Missing/ Did not Report	38557	56.0%

¹ For these 10923 participants, the mean number of children enrolled in a public school was 1.61 (minimum=0.00, 25th percentile=1.00, median=1.00, 75th percentile=2.00, maximum=4.00). Furthermore, among these 10923 responders, 676 (6.2%) had zero kids enrolled in public schools.

² Non-essential jobs

Statistical Analysis

In the study, we assessed the association between getting the vaccine (outcome) and a number of explanatory factors (exposures): a participant’s having COVID-19 in the past, their gender, how much formal education they obtained, having children enrolled in public school, their yearly household income, if they identify as Hispanic or not, and the industry sector they are employed in. To be able to assess the association of vaccination status with each individual exposure factor, the data were organized into a 2 by 2 table (Figure 1).

In Figure 1, cell “a” would correspond to those who had chosen “yes” for the specific exposure being looked at, as well as “yes” to the vaccination question. Cell “b” would be “yes” to the exposure and “no” to the vaccine. Cell “c” would be “no” to the exposure, but “yes” to the vaccine. Cell “d” would be “no” to both the vaccine and exposure. Then taking this information gathered from the tables, the Odds

Ratio (OR) was calculated. To do this the odds of certain exposure to both the “yes” (vaccinated) and “no” (not vaccinated) categories for the outcome were needed. Then the OR was found by dividing them by each other. From the numerical values gathered, an association of an exposure factor to vaccination status was able to be assessed. An OR of 1 means there is no association. Anything below 1 indicates a negative association, while anything above 1 indicates a positive association.

		Outcome	
		Vaccinated	Unvaccinated
Exposure	Yes	a	b
	No	c	d

Figure 1. An example of the 2x2 table template used in the investigation.

The 95% confidence interval (CI), corresponding to the p-value of 0.05, is used as an indicator to tell if the OR of the same value is statistically significantly above or below the null value of 1. The 95% CI was estimated as a large sample normal approximation and using variance based on a Taylor series expansion [8]. It was calculated using the following equations, where a, b, c and d are explained in Figure1, and $var(\ln OR)$ is the Taylor series approximation of OR variance:

$$Error\ Factor = e^{1.96\sqrt{var(\ln OR)}}, \text{ where } var(\ln OR) = 1/a + 1/b + 1/c + 1/d$$

$$Lower\ Limit = OR / Error\ Factor$$

$$Upper\ Limit = OR \times Error\ Factor$$

If the 95% CI does not include 1, this means that the factor is statistically significantly associated with the outcome, whereas if it does include 1 it means that the factor is not statistically significantly associated with the outcome [9].

Results

In total, 68,913 people participated in the study. Out of those participants, we excluded 392 who did not respond to the vaccination question (outcome of interest). Thus, 68,521 responses were analyzed.

Overall, 78.9% of participants were vaccinated, 11.2% had COVID-19 ever, 40.6% were male, 13.3% were high school graduates or below, 33% had a household income of \$74,999 or below, and 90.4% did not identify as Hispanic (Table 1). In total, 15.9% (10,923) responded to the question about whether or not they have children enrolled in a public school. Among them, the mean number of children enrolled in a public school was 1.61 (median=1.00). Dichotomizing this factor into two levels, those with and those without children in the public school, indicated that 6.2% of all participants who responded to this question (i.e., 10,923) had no kids in the public school, while the rest of responders had one or more children in the public school. Among participants, the lowest percent vaccinated was in the US Postal Service (65.2%) while the

highest was in K-12 schools (86.0%) (Figure 2). An association between getting the vaccine (outcome) and the exposure factors were assessed by calculating an OR and the associated 95% CI (Table 2); as a reminder, a 95% CI that excludes the null value of one indicates a statistically significant (positive or negative) association at the p-value of 0.05 significance level. The OR between vaccination and whether or not a person had COVID-19 had the mean of 0.43 (95% CI: 0.41-0.43), meaning there was a statistically significant negative association between the two indicating that someone who has not been diagnosed with the virus is less likely to have received the vaccination. For gender, the OR was 1.12 (95% CI: 1.01-1.15) which is a positive association. This implies that participants were more likely to get the vaccine if they were a male; although statistically significant, this was a relatively weak association. Education level had a statistically significant positive association with the mean OR of 2.40 (95% CI: 2.36-2.48). This association shows that participants who completed at least some college education were more likely to get vaccinated. Having children enrolled in public school had a statistically significant negative association with the mean OR of 0.77 (95% CI: 0.68-0.83) meaning that those who had kids enrolled in public school were less likely to get the vaccine than those who had kids enrolled in private school or whose kids were homeschooled. Income had a statistically significant positive association with a mean OR of 2.20 (95% CI: 2.15-2.25) showing that those with a greater household income were more likely to get the vaccine. Also, whether or not a person identifies as Hispanic had a statistically significant negative association with the mean OR of 0.72 (95% CI: 0.70-0.74) indicating that those who do not identify as Hispanic were more likely to have received the vaccine.

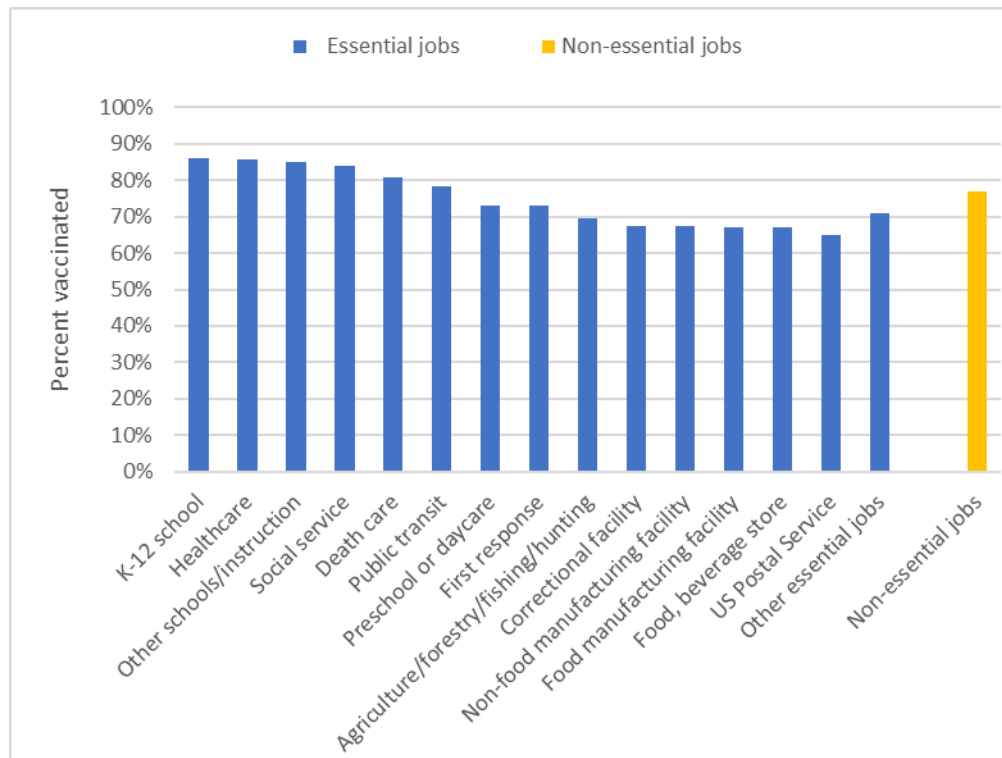


Figure 2. Percent vaccinated from each sector of work represented in the US Census’s Household Pulse Survey.

Table 2. Cross-tabulated data with calculated Odds Ratios and 95% confidence intervals (95% CIs). Variable names are defined in Table 1.

		vac		
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		yes	no	Odds ratio	95% CI
hadcovid	yes	4939	2731	0.43	0.41-0.43
	no	49368	11411		
gender	male	22384	5417	1.12	1.01-1.15
	female	31975	8745		
educ	yes	48452	10938	2.40	2.36-2.48
	no	5907	3224		
kids	yes	7264	2969	0.77	0.68-0.8
	no	514	158		

income	yes	30474	5606	2.20	2.15-2.25
	no	10050	4063		
hispanic	yes	4855	1704	0.72	0.70-0.7
	no	49504	12458		

To compare the different sectors of work and their likelihood to obtain the vaccine, each sector was placed in one of three different groups: blue, pink, and white collar (Table 3). Next, vaccination in the blue collar vs white collar jobs was compared to find an OR of 0.38 (95% CI: 0.36-0.40). This demonstrates that participants in blue collar job sectors were statistically significantly less likely to be vaccinated compared to those in white collar jobs. Pink collar vs white collar had an OR of 0.95 (95% CI: 0.90-1.00), implying that those in the pink collar job sector were less likely to be vaccinated in comparison to the participants in the white collar sector, but the association is only borderline significant (upper limit of the 95% CI touches the null value of one). Lastly, blue collar vs pink collar had an OR of 0.40 (95% CI: 0.38-0.42), which indicates that those in blue collar jobs were statistically significantly less likely to be vaccinated compared to those in pink collar jobs.

Table 3. Number vaccinated compared to unvaccinated in blue, pink, and white collar essential job sectors.

Job Sector	vac		% vaccinated
	yes	no	
White collar	5,990	1,030	85.33%
Pink collar	3,729	675	84.67%
Blue collar	2,949	1,342	68.73%

Discussion

This study was conducted to examine the main differences between those who received the COVID-19 vaccination in comparison to those who did not receive the vaccination in the USA in the early period of vaccine availability, using publicly available HPS data collected from April 14th - July 5th of 2021. Our main findings were that those who had not been infected by COVID-19, who had less overall household incomes, obtained less education, identified as Hispanic, identified as female, and who worked in the industry sectors with primary blue-collar jobs were all less likely to receive the vaccination against COVID-19. In the following paragraphs, we discuss our findings.

The information obtained from the odds ratios indicated that a person who never had COVID-19 is less likely to get the vaccination. Overall, 78.9% of the people in this study were vaccinated. A study on vaccination hesitancy explains that when individuals believe that they are at an increased risk, they are more likely to take measures to decrease that risk, including getting vaccinated against COVID-19, suggesting that when the risk becomes real to a person, they are more likely to take action to protect themselves [10]. One may conclude that those who have already contracted the virus get the vaccination in fear of worsening symptoms. There were some speculations around if you should take the vaccine if you already have some immunity after being infected with the virus, but the Centers for Disease Control and Prevention recommends getting the vaccine even if you have already had COVID-19 [11]. This is because there is still a high likelihood of contracting the mutating virus again without the vaccination with a possibility of health complications.

The association between vaccination status and the total household incomes indicates that those with lower overall incomes were less likely to get vaccinated. A study on poverty and COVID-19 explains that people living in lower income statuses have lower quality health care [12]. This suggests that socioeconomic status impacts one's willingness to get the vaccine, as supported in [13]. In communities of lower socio-economic status, COVID-19 was more likely to spread there since there was far less access to COVID-19 tests and vaccination sites in comparison to more affluent neighborhoods [12]. These findings indicate that there should be an emphasis on educating those in lower socio-economic statuses (especially those without access to health professionals) on matters concerning safety and effectiveness of vaccinations since the COVID-19 vaccination is free and meant to be available to all Americans.

The association between receiving the vaccine and years of formal education attained demonstrates that those who received lower levels of education were less likely to get vaccinated against COVID-19. A study by Daly and Robinson explains that people who did not graduate college or obtain a college degree had a higher risk of being unwilling to get the COVID-19 vaccination [14]. The study looked at 13 surveys from a US based sampling of over 7,500 adults. It pointed out that there was a drastic contrast in one's willingness to receive the vaccine between those who are of higher income and have college degrees, versus those who do not. These findings show the need for more education going towards individuals without college degrees to assure and educate individuals on the safety and effectiveness of vaccinations.

Our findings revealed that people who identify as Hispanic were less likely to get the vaccination, in comparison with those who do not. An article published by the Journal of Racial and Health Disparities states that Hispanic families suffered many more financial difficulties from the pandemic in comparison to the other racial groups [15]. While the largest concerns of getting the vaccine were with side effects and safety, there was a substantial percentage of people who were concerned about the cost of a COVID-19 vaccination, when in reality the vaccine is free. However, it may be that their concerns were due to the costs associated with the time lost to getting vaccinated or the fear of the unavailability to work because of the potential vaccine side-effects. This supports the idea that there needs to be more education directed at Hispanic communities and lower income communities in general, and improving access to vaccination. Since many Hispanics live in lower income communities, they have less access to healthcare and information about the virus overall. Additionally, many Hispanics may find transportation a barrier in getting the vac-

cine as many of the lower-income families rely on public transportation. This caused an issue for many families as in a lot of cities public transportation had to be stopped during the pandemic for a prolonged period of time [16].

The association between getting the vaccine and gender indicated that females were statistically less likely to receive the vaccination in comparison to males. This finding was contrary to our hypothesis. However, to support our findings, an article by Paul et al. states that women and those living with children were more likely to hesitate to get the vaccine [17]. As the main identified behavioral barrier, women seemed more likely to not trust the benefits and safety of the vaccination.

We compared vaccination among participants in the blue, pink, and white collar essential jobs sectors. Those working in the blue collar job sector were less likely to receive the vaccination in comparison to those working in white and pink collar job sectors. Furthermore, there was a borderline significant association between vaccination in the pink vs white collar job sectors. A paper by Dorman et al. states that those working in blue collar jobs were less likely to receive the vaccination in comparison to white collar jobs [18]. The main factor for their unwillingness was concerns about the safety of the vaccine. Pink collar jobs may have had lower levels of vaccination in comparison to white collar jobs because of the fact that the education system has more women working than men. As of 2022, 76% of all K-12 teachers in the US are women [19]. As stated in the previous paragraph, women were less likely to get the vaccine due to behavioral barriers.

Conclusion

Overall, in the period early after COVID-19 vaccines became available in the USA, individuals who received the COVID-19 vaccination were more likely to be those who were at some point diagnosed with COVID-19, identified as male, received a greater level of education, had children who were not enrolled in public school, had a greater household income, and those who did not identify as Hispanic. Participants in the blue collar job sector were less likely to be vaccinated in comparison to pink and white collar job sectors. These findings can help point out weak points in vaccine acceptance, and are a good representation of what issues the country had during the initial months of vaccine deployment.

Limitations

It is important to discuss the limitations of this study such as sample population and bias to further understand the results. This study was done using the data from the Census' HPS. Due to its rapid deployment, as mentioned before, the data is at risk of being slightly inaccurate [6]. Another source of bias may be the study itself in the form of a selection bias, since it is possible that those who agreed to take the survey were more likely to be vaccinated. Thus, those who were unvaccinated may have been unwilling to participate in the survey for fear of reprisal. Since the survey was not mandatory, those who were already vaccinated might have been more willing to take the survey believing that they would assist in educating others on the importance of vaccination.

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