An Investigation of U.S. COVID-19 Vaccination Rates as a Political Issue

QMSS GR5015 Independent Project
Yanji Du

Introduction

One of the defining aspects of ex-President Trump's and President Biden's legacy, as well as the 2020 U.S. Presidential Election, was the response and attitudes towards the novel COVID-19 pandemic. In an era of increasingly divisive (i.e. "us vs. them") politics and political identities, even public health policies were suddenly thrust into the spotlight as political issues, perhaps historically never as significantly.

It was clear there was intense disagreement amongst Americans regarding the best course of action and response towards the pandemic. Left-leaning voters tended to favor more restrictive measures (e.g. the closing of businesses, potential testing and/or vaccine mandates) to facilitate disease control, while right-leaning voters tended to favor less restriction to support personal freedom and choice. [1]

Shortly after the 2020 U.S. Presidential Election in December 2020, the FDA granted Emergency Use Authorization (EUA) for the first COVID-19 vaccines [2]. Despite being one of the first nations to develop and distribute the vaccine, currently at the end of 2021 after nearly a year following this first vaccine EUA, U.S. COVID-19 vaccination rates lag behind other developed nations [3].

This study investigates whether U.S. COVID-19 vaccination rates are a political issue: do Americans' willingness to get vaccinated correlate with political party affiliation? This research views vaccination compliance as an extension of pandemic response views which were highlighted during the 2020 U.S. Presidential Election: there is arguably nothing more invasive, but also helpful, in containing the pandemic than injecting a medical compound into your body.

As such, we hypothesize that vaccination rates (dependent variable) do correlate with how Americans voted in the 2020 U.S. Presidential Election (independent variable). Since individual voting and vaccination data are not available, we examine this at the county aggregation level: we hypothesize that counties that had a higher Democrat vote percentage will have higher vaccination rates. Further, we also examine whether vaccination rates are correlated with a *shift* in percentage points that voted Democrat vs. Republican, from the 2016 U.S. Presidential Election compared to the 2020 U.S. Presidential Election. Our hypothesis for

this question is that pandemic response became such a hotly-debated issue that vaccination rates may even be correlated with political party polarization from 2016 to 2020 (rather than just point-in-time affiliation).

Description of Data Set and Variables

We track and join data at the U.S. county aggregation level using FIPS county codes [4].

U.S. COVID-19 vaccination rates at the county level are tracked and compiled by the Centers for Disease Control and Prevention (CDC) [5]. Data represents all vaccine partners including jurisdictional partner clinics, retail pharmacies, long-term care facilities, dialysis centers, Federal Emergency Management Agency and Health Resources and Services Administration partner sites, and federal entity facilities. Our primary metric of interest is “Series_Complete_Pop_Pct”: percent of people who are fully vaccinated (have second dose of a two-dose vaccine or one dose of a single-dose vaccine) based on the jurisdiction and county where the recipient lives. While the data can be examined as a time-series, we chose a specific date: November 29, 2021. This was the date that the CDC expanded recommendation for all adults to receive a booster vaccine shot [6]. At this point in time, we assume that the majority of all adult Americans who truly wanted and are able to get vaccinated had the appropriate amount of time to do so, while those who did not want to get vaccinated may never get vaccinated.

U.S. Presidential Election results at the county level in 2016 and 2020 were tracked and compiled by the MIT Election Data and Science Lab (MEDSL) [7]. We calculate percentage Democrat and Republican votes by dividing over the sum of the Democrat and Republican votes in each county (ignoring third party/alternative candidate votes). We define pct_shift_dem_2016_to_2020 as the percentage point change in 2020 election Democrat vote % - 2016 election Democrat vote % (positive means a higher percentage of voters voted Democrat in 2020 than in 2016).

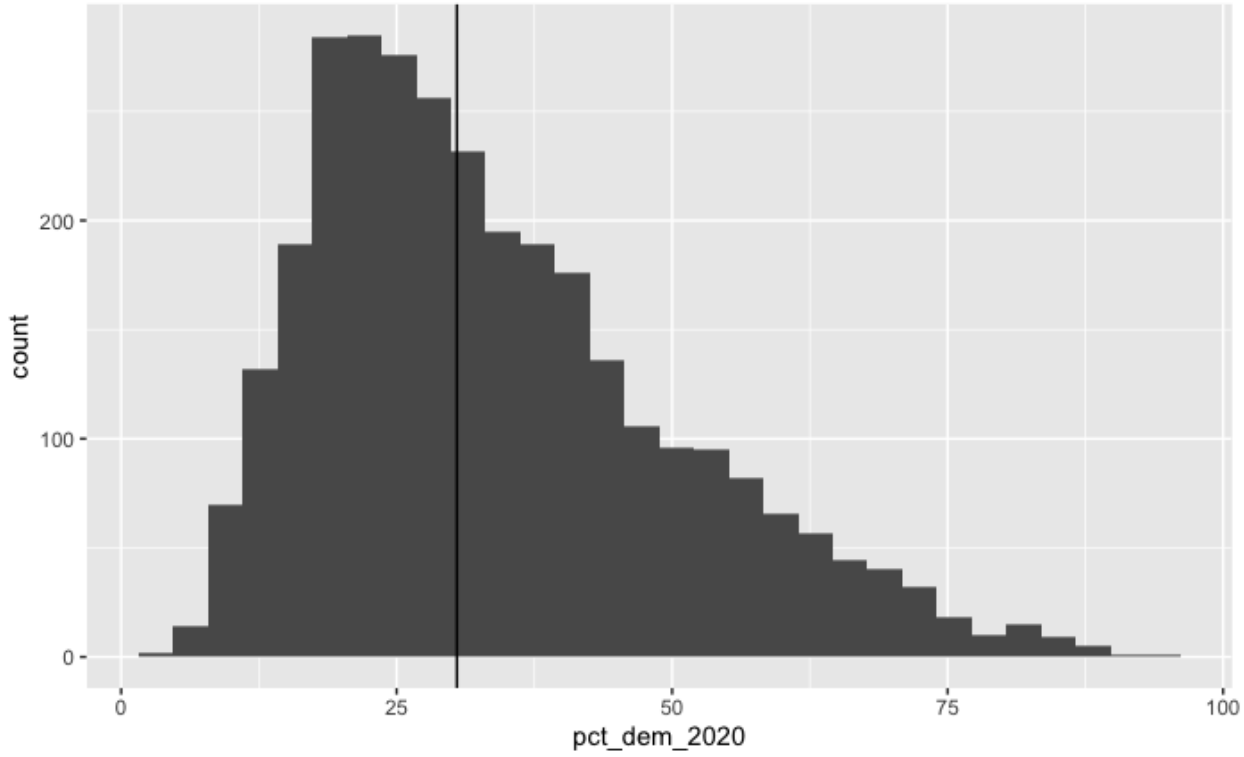
We also track potential confounding variables at the county level using the dataset “County-level Socioeconomic Data for Predictive Modeling of Epidemiological Effects” compiled by students from Johns Hopkins University [8]: demographics (age and gender), educational attainment, and poverty and household income. The time period from which the source data were pulled does not always perfectly match our study period (2020-2021) but are reasonably close (from the last few years). We assume that county-level attributes like demographics do not change too significantly over the past few years.

Table 1: Data Description

Source	Variable Name	Data Type	Description
CDC	Series_Complete_Pop_Pct	Numeric [0, 100]	Percent of people who are fully vaccinated (have second dose of a two-dose vaccine or one dose of a single-dose vaccine) based on the jurisdiction and county where the recipient lives. Taken on 11/29/21.
MEDSL	pct_dem_2020	Numeric [0, 100]	Percent of people who voted Democrat in the 2020 US Presidential Election.
MEDSL	pct_shift_dem_2016_to_2020	Numeric [-100, 100]	Change in percentage of people who voted Democrat in the 2016 US Presidential Election compared with the 2020 election.
JHU	educ_perc_bachelor_or_higher	Numeric [0, 100]	Percent of people who attained a Bachelor's degree or higher education level.
JHU	poverty_perc	Numeric [0, 100]	Percent of people defined to be in poverty.
JHU	household_income_median_log	Numeric	Log transform of median household income.
JHU	gender_male_perc	Numeric [0, 100]	Percent of people who are males.
JHU	age_65plus_perc	Numeric [0, 100]	Percent of people who are age 65 or older.

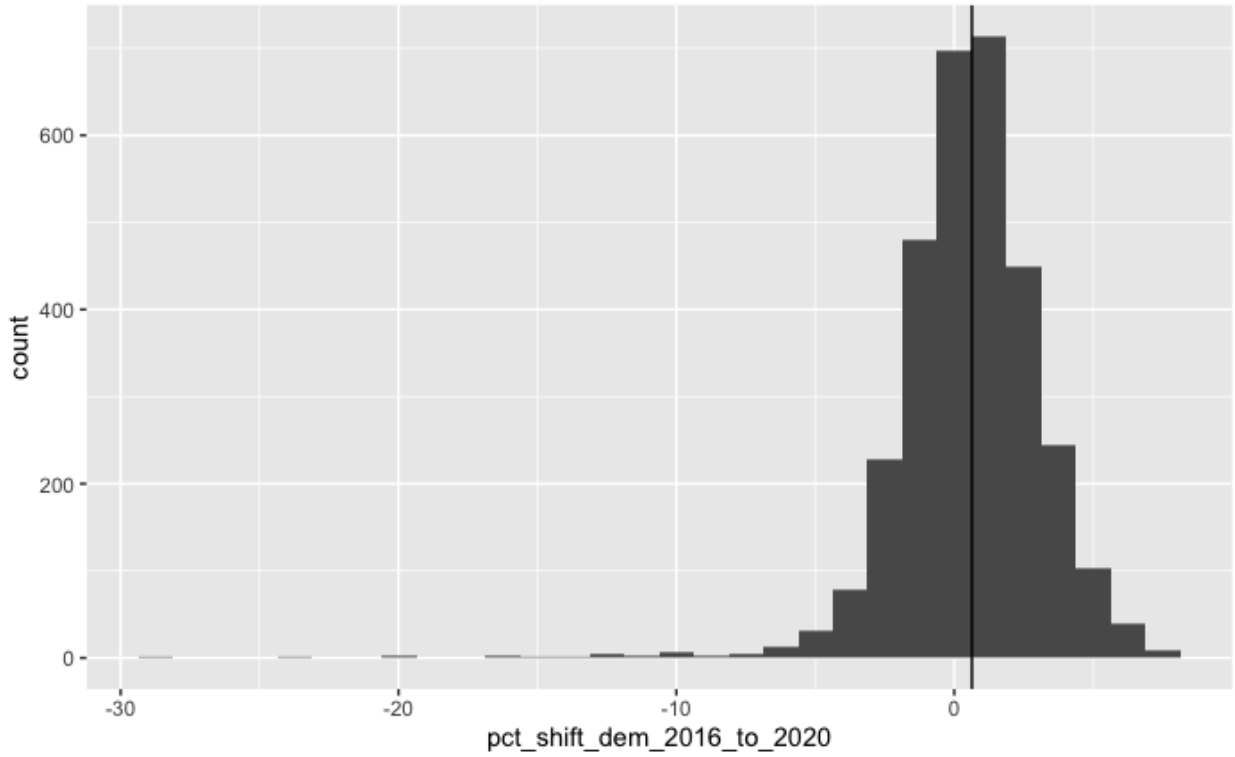
Descriptive Statistics

Fig. 1: Distribution of counties by percentage Democrat vote in 2020 U.S. Presidential Election



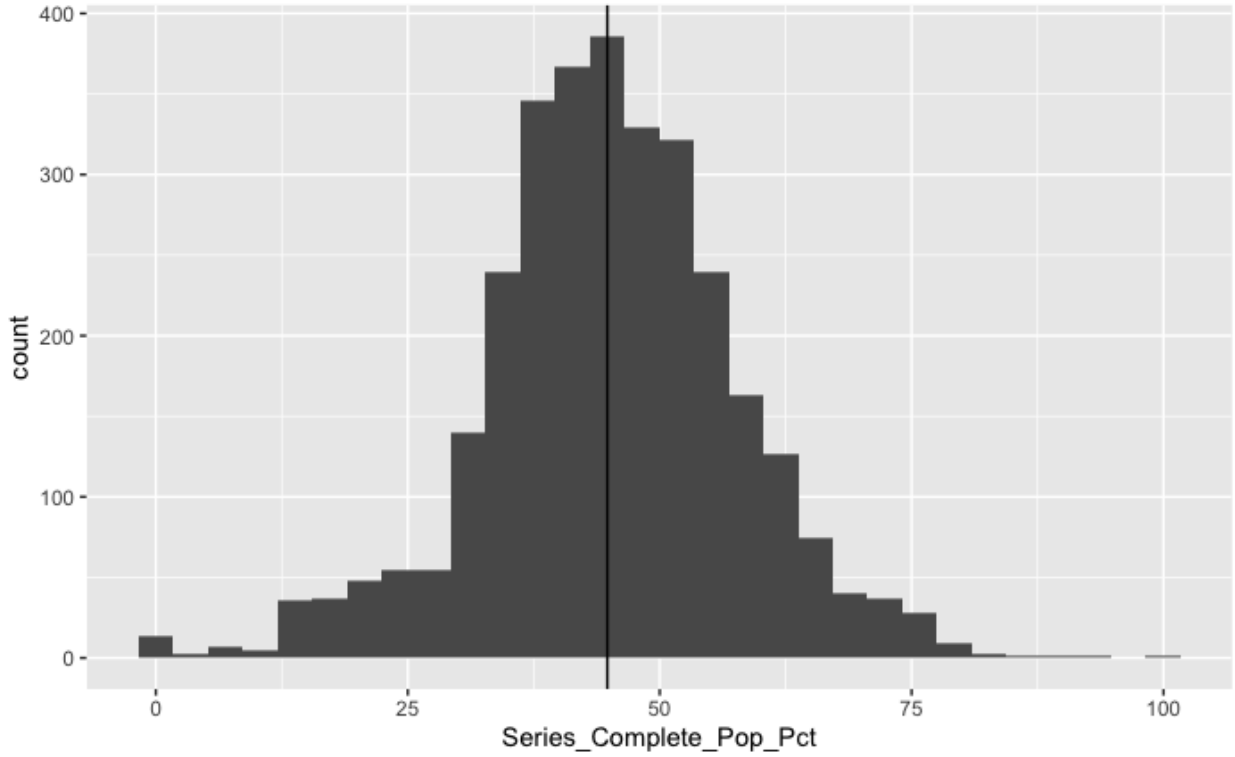
We see that the median percentage Democrat vote in 2020 was around 30%, an interesting result considering the Democrat party won the election. Note that in the U.S., electoral votes are awarded at the state level (not county level), and cities/populated urban areas are more likely to be left-learning (and represented as fewer counties).

Fig. 2: Distribution of counties by percentage shift in Democrat vote from 2016 to 2200



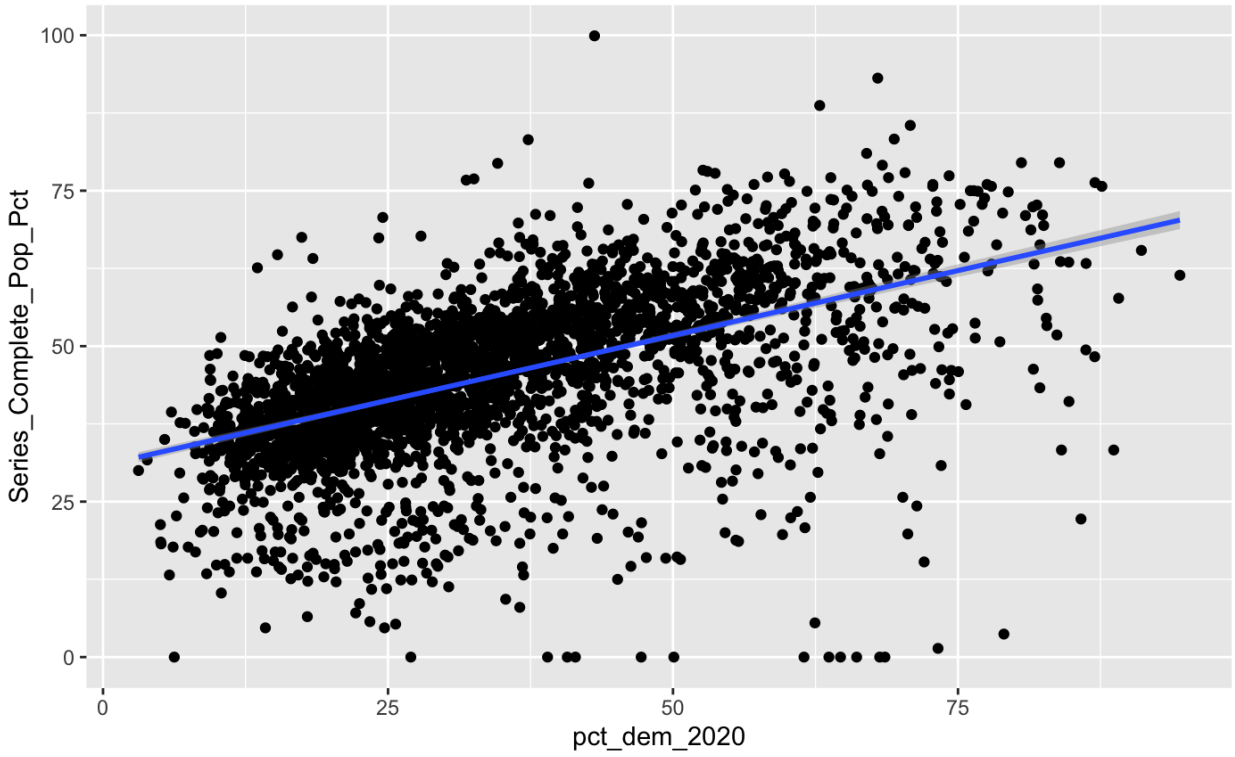
We see the distribution is roughly centered on 0 with a slight shift towards the positive side (meaning there were slightly more counties that increased the percentage of Democrat votes in 2020 as compared to 2016). Interestingly there were quite a few counties that significantly reduced the percentage of Democrat votes in 2020 (more extreme than -10%), but we didn't see any counties doing the inverse.

Fig. 3: Distribution of counties by vaccination completion rates



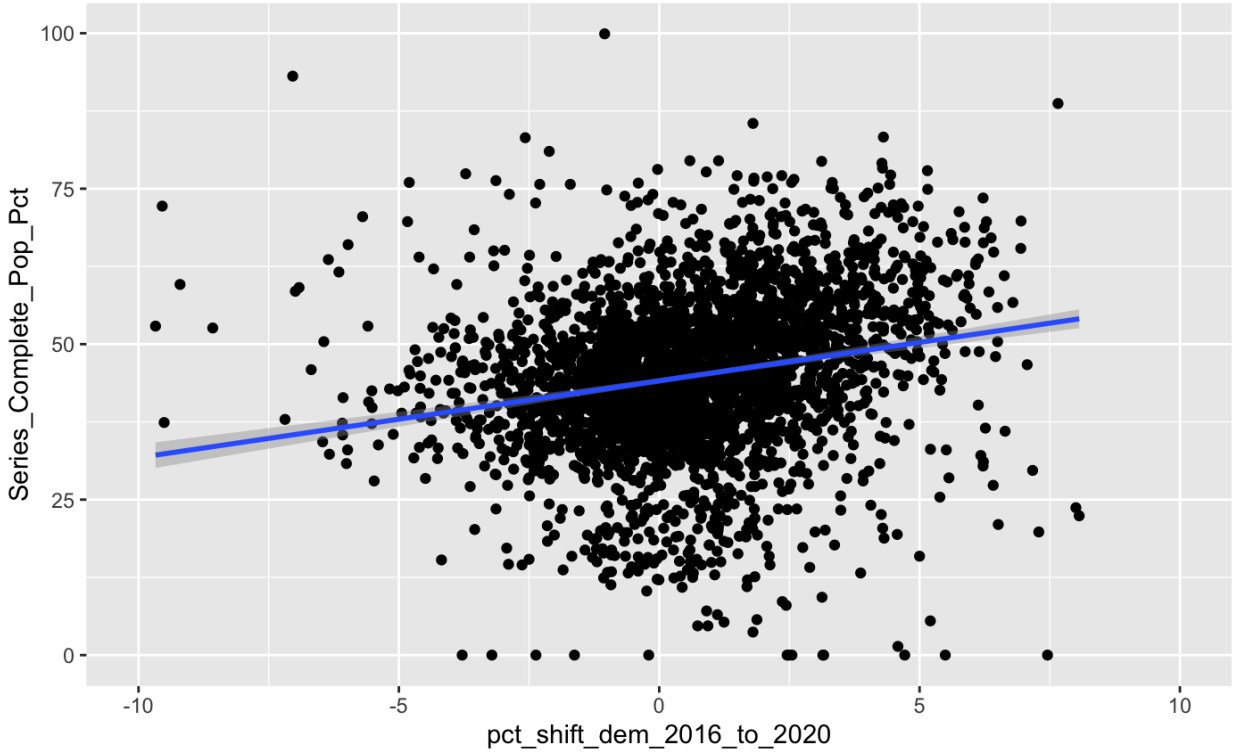
We see the median vaccination rate is just under 50% by county.

Fig. 4: Scatterplot of counties by Vaccination Rate vs. Democrat Vote % in 2020



We see a fairly clear positive linear trend at the county-level between Democrat Vote % in 2020 as the independent variable and Vaccination Rate (as of 11/29/21) as the dependent variable. We'll explore this in more detail in the below sections via regression methods.

Fig. 5: Scatterplot of counties by Vaccination Rate vs. Pct Shift in Democrat Vote % in 2020 vs. 2016



The linear relationship between Pct Shift in Democrat Vote % in 2020 vs. 2016 as the independent variable and Vaccination Rate (as of 11/29/21) as the dependent variable is less immediately clear; however there does appear to be some trend. We'll explore this in more detail in the below sections via regression methods.

Table 2: Summary of all variables (including descriptive and potential confounding variables)

```
 county_fips    county_name          state             state_po         votes_2020_total   pct_dem_2020     pct_dem_2016
Min.   : 1001   Length:3113        Length:3113        Length:3113        Min.   :     66   Min.   : 3.114   Min.   : 3.247
1st Qu.:19035   Class :character   Class :character   Class :character   1st Qu.:   5372   1st Qu.:21.237   1st Qu.:21.331
Median :29205   Mode  :character   Mode  :character   Mode  :character   Median :  12540   Median :30.470   Median :29.928
Mean   :30627                                                           Mean   :  50663   Mean   :33.878   Mean   :33.324
3rd Qu.:46003                                                           3rd Qu.:  33629   3rd Qu.:43.125   3rd Qu.:42.270
Max.   :56045                                                           Max.   :4264365   Max.   :94.467   Max.   :95.695

pct_shift_dem_2016_to_2020 Series_Complete_Pop_Pct Series_Complete_Yes Completeness_pct Rural.urban_Continuum.Code_2013 POP_ESTIMATE_2018
Min.   :-28.1611           Min.   : 0.00          Min.   :      0     Min.   : 0.00    Min.   :1.000                  Min.   :     152
1st Qu.: -0.7801           1st Qu.:37.70          1st Qu.:   4328     1st Qu.:92.60    1st Qu.:2.000                  1st Qu.:   11127
Median :  0.6353           Median :44.80          Median :  11098     Median :96.70    Median :6.000                  Median :   26139
Mean   :  0.5540           Mean   :44.99          Mean   :  58325     Mean   :92.43    Mean   :4.987                  Mean   :  104710
3rd Qu.:  2.0309           3rd Qu.:52.80          3rd Qu.:  32626     3rd Qu.:97.90    3rd Qu.:7.000                  3rd Qu.:   68362
Max.   :  8.0659           Max.   :99.90          Max.   :6426926     Max.   :99.90    Max.   :9.000                  Max.   :10105518

educ_perc_less_than_high_school educ_perc_high_school educ_perc_some_college educ_perc_bachelor_or_higher  poverty_perc   household_income_median
Min.   : 1.20                   Min.   : 5.50         Min.   : 5.80          Min.   : 0.00               Min.   : 2.60   Min.   : 25385
1st Qu.: 8.80                   1st Qu.:29.80         1st Qu.:27.20          1st Qu.:15.00               1st Qu.:10.80   1st Qu.: 43651
Median :12.10                   Median :34.60         Median :30.60          Median :19.20               Median :14.10   Median : 50531
Mean   :13.43                   Mean   :34.29         Mean   :30.72          Mean   :21.56               Mean   :15.16   Mean   : 52714
3rd Qu.:17.20                   3rd Qu.:39.30         3rd Qu.:34.20          3rd Qu.:25.60               3rd Qu.:18.30   3rd Qu.: 58648
Max.   :66.30                   Max.   :55.60         Max.   :57.30          Max.   :78.50               Max.   :48.40   Max.   :140382

household_size_avg gender_male_perc age_0to17_perc   age_18to64_perc age_65plus_perc POP_ESTIMATE_2018_log household_income_median_log
Min.   :1.900      Min.   :43.13    Min.   : 7.069   Min.   :35.34   Min.   : 4.83   Min.   : 5.024        Min.   :10.14
1st Qu.:2.410      1st Qu.:48.97    1st Qu.:20.032   1st Qu.:56.33   1st Qu.:16.33   1st Qu.: 9.317        1st Qu.:10.68
Median :2.550      Median :49.68    Median :22.074   Median :58.56   Median :18.96   Median :10.171        Median :10.83
Mean   :2.589      Mean   :50.09    Mean   :22.049   Mean   :58.64   Mean   :19.31   Mean   :10.288        Mean   :10.84
3rd Qu.:2.710      3rd Qu.:50.57    3rd Qu.:23.842   3rd Qu.:60.75   3rd Qu.:21.82   3rd Qu.:11.133        3rd Qu.:10.98
Max.   :4.110      Max.   :73.16    Max.   :41.992   Max.   :82.90   Max.   :57.59   Max.   :16.129        Max.   :11.85
NA's   :2289
```

The above figure shows the mean, median, min/max, and quartile distribution of all variables included in our research, including some that we'll use as confounders.

In general, we see most counties are relatively similar in the interquartile range (e.g. comparing the 25th percentile and 75th percentile county). While there are slight differences, they don't appear to be exceedingly large.

However, when we look at the counties at the tail ends of the distributions, there does appear to be quite large differences. Some factors like age_65plus_perc, the percentage of the population age 65 or older), can range from as low as 4.8% to as high as 57.6%. This factor is likely highly correlated with vaccination rates since elderly population is more susceptible to death from COVID-19 than younger adults, we should be sure to control for factors like this and the others stated in Table 1.

We took the log transform of variables like median household income to ensure our variables are roughly the same scale when using regression below.

Initial Models

LM Fit 1A: Linear regression of Vaccination Rates vs. Democrat Vote % in 2020
(Without confounding variables)

```
Call:
lm(formula = Series_Complete_Pop_Pct ~ pct_dem_2020, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-60.129  -4.197   1.261   6.516  51.056

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  30.85289    0.44142   69.89   <2e-16 ***
pct_dem_2020  0.41728    0.01174   35.53   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.67 on 3111 degrees of freedom
Multiple R-squared:  0.2887,    Adjusted R-squared:  0.2884
F-statistic:  1262 on 1 and 3111 DF,  p-value: < 2.2e-16
```

First, we try a simple linear regression model just regressing our independent variable of Democrat Vote % in 2020 on the dependent variable of Vaccination Rates at the county-level.

We observed:

- Pct_dem_2020 coefficient estimate of 0.41728, meaning for each 1% increase in Democrat Vote % in 2020 at the county level, there was roughly a 0.4% increase in vaccination rate, on average. The association is positive, meaning that the more Democrat a county leaned, the higher the vaccination rates in the county.
- The coefficient is statistically significant at the 0.05 level with a p-value of <2e-16, meaning we can reject the null hypothesis of no association between Vaccination Rate and Democrat Vote % in 2020.
- The adjusted R-squared value is 28.8%, referring to the level of variation in the data explained by our covariates. Considering we only included one variable, we consider this to be surprisingly high in terms of our initial expectations.

LM Fit 2A: Linear regression of Vaccination Rates vs. Percent Shift in Democrat Vote in 2020 from 2016
(Without confounding variables)

```
Call:
lm(formula = Series_Complete_Pop_Pct ~ pct_shift_dem_2016_to_2020,
    data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-50.035  -6.962   0.029   7.524  56.081

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                44.58456    0.22924 194.490   <2e-16 ***
pct_shift_dem_2016_to_2020  0.73078    0.08676   8.423   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 12.51 on 3111 degrees of freedom
Multiple R-squared:  0.0223,    Adjusted R-squared:  0.02198
F-statistic: 70.94 on 1 and 3111 DF,  p-value: < 2.2e-16
```

Next, we try a simple linear regression model just regressing our independent variable of Percent Shift in Democrat Vote in 2020 from 2016 on the dependent variable of Vaccination Rates at the county-level.

We observed:

- pct_shift_dem_2016_to_2020 coefficient estimate of 0.73078, meaning for each 1% increase in Percent Shift in Democrat Vote in 2020 from 2016 at the county level (1% more a county voted Democrat in 2020 as compared to 2016), there was roughly a 0.7% increase in vaccination rate, on average. The association is positive, meaning that the more Democrat a county leaned in 2020 as compared to 2016, the higher the vaccination rates in the county.
- The coefficient is statistically significant at the 0.05 level with a p-value of <2e-16, meaning we can reject the null hypothesis of no association between Vaccination Rate and Percent Shift in Democrat Vote in 2020 from 2016.
- The adjusted R-squared value is 2.2%, referring to the level of variation in the data explained by our covariates. This is considerably lower than LM Fit 1A, and something we expected given our initial data exploration using scatter plot in Fig. 5.

Final Models

In our final models, we also adjust for covariates that may be confounding the relationship between vaccination rates and how counties voted in the 2020 election. The confounding variables were listed in Table 1, and are again listed below for reference.

- educ_perc_bachelor_or_higher
- poverty_perc
- household_income_median_log
- gender_male_perc
- age_65plus_perc

The variables are demographic (age and gender), educational attainment, poverty status, and median household income.

LM Fit 1B: Linear regression of Vaccination Rates vs. Democrat Vote % in 2020
(with confounding variables)

```
Call:
lm(formula = Series_Complete_Pop_Pct ~ pct_dem_2020 + educ_perc_bachelor_or_higher +
    poverty_perc + household_income_median_log + gender_male_perc +
    age_65plus_perc, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-68.356  -3.558   1.188   5.255  47.701

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                 14.65551   23.30529   0.629    0.529
pct_dem_2020                 0.41138    0.01487  27.656  < 2e-16 ***
educ_perc_bachelor_or_higher  0.16813    0.03188   5.275 1.42e-07 ***
poverty_perc                -0.51402    0.07225  -7.114 1.39e-12 ***
household_income_median_log  -0.67753    2.11447  -0.320    0.749
gender_male_perc             0.45399    0.08313   5.461 5.10e-08 ***
age_65plus_perc              0.26758    0.04607   5.808 6.97e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.86 on 3106 degrees of freedom
Multiple R-squared:  0.3932,    Adjusted R-squared:  0.3921
F-statistic: 335.5 on 6 and 3106 DF,  p-value: < 2.2e-16
```

We observed:

- Pct_dem_2020 coefficient estimate of 0.41138, meaning for each 1% increase in Democrat Vote % in 2020 at the county level, there was roughly a 0.4% increase in vaccination rate, on average, and holding all other factors constant. The association is positive, meaning that the more Democrat a county leaned, the higher the vaccination rates in the county.
- The coefficient is statistically significant at the 0.05 level with a p-value of <2e-16, meaning we can reject the null hypothesis of no association between Vaccination Rate and Democrat Vote % in 2020, while adjusting for confounders.
- The adjusted R-squared value is 39.2%, referring to the level of variation in the data explained by our covariates. Adding the covariates increased the R-squared value.
- Other observations regarding confounding factors:
    - All confounder factors are statistically significant, except for median household income.
    - Poverty status appears to negatively correlated with vaccination rates on average, holding all other factors constant. This could potentially be because those in poverty may not have the means to take off work to get vaccinated, or

perhaps cannot easily access a vaccination clinic, or potentially fear the perceived cost and health insurance issues.
    - All other statistically significant confounding factors appear to be positively correlated with vaccination rates on average, holding all other factors constant.

```
Analysis of Variance Table

Model 1: Series_Complete_Pop_Pct ~ pct_dem_2020
Model 2: Series_Complete_Pop_Pct ~ pct_dem_2020 + educ_perc_bachelor_or_higher +
    poverty_perc + household_income_median_log + gender_male_perc +
    age_65plus_perc
  Res.Df    RSS Df Sum of Sq      F    Pr(>F)
1   3111 353992
2   3106 301946  5     52046 107.07 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

We verify that adding covariates in LM Fit 1B produced a better informed model than LM Fit 1A using ANOVA. We see the p-value of < 2.2e-16, statistically significant at the 0.05 level.

LM Fit 2B: Linear regression of Vaccination Rates vs. Percent Shift in Democrat Vote in 2020 from 2016
(with confounding variables)

```
Call:
lm(formula = Series_Complete_Pop_Pct ~ pct_shift_dem_2016_to_2020 +
    educ_perc_bachelor_or_higher + poverty_perc + household_income_median_log +
    gender_male_perc + age_65plus_perc, data = df)

Residuals:
    Min      1Q  Median      3Q     Max
-64.133  -5.270   0.895   6.455  49.097

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  -75.67924   25.48525  -2.970  0.00301 **
pct_shift_dem_2016_to_2020    -0.70808    0.08997  -7.870 4.85e-15 ***
educ_perc_bachelor_or_higher   0.65063    0.03312  19.647  < 2e-16 ***
poverty_perc                   0.13822    0.07500   1.843  0.06543 .
household_income_median_log    9.19943    2.30118   3.998 6.55e-05 ***
gender_male_perc               0.02675    0.09034   0.296  0.76716
age_65plus_perc                0.19961    0.05086   3.925 8.87e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.9 on 3106 degrees of freedom
Multiple R-squared:  0.2586,    Adjusted R-squared:  0.2572
F-statistic: 180.6 on 6 and 3106 DF,  p-value: < 2.2e-16
```

We observed:

- pct_shift_dem_2016_to_2020 coefficient estimate of -0.70808, meaning for each 1% increase in Percent Shift in Democrat Vote in 2020 from 2016 at the county level (1% increase in Democrat votes in 2020 from 2016), there was roughly a 0.7% decrease in vaccination rate, on average, and holding all other factors constant. The association is negative, meaning that the more Democrat a county leaned in 2020 as compared to 2016, the lower the vaccination rates in the county.
    - This is an interesting result where the sign of the association from LM Fit 2A (previously positive) changed to negative. Also noteworthy is the sign of the independent variable of interest in LM Fit 1A vs. LM Fit 1B (pct_dem_2020) did not change sign (remained positive).
- The coefficient is statistically significant at the 0.05 level with a p-value of 4.85e-15, meaning we can reject the null hypothesis of no association between Vaccination Rate and Percent Shift in Democrat Vote in 2020 from 2016, while adjusting for confounders.
- The adjusted R-squared value is 25.7%, referring to the level of variation in the data explained by our covariates. Adding the covariates increased the R-squared value as compared to LM Fit 2A.

- Other observations regarding confounding factors:
    - All confounder factors are statistically significant, except for percent poverty and percent male.
    - All other statistically significant confounding factors appear to be positively correlated with vaccination rates on average, holding all other factors constant.

```
Analysis of Variance Table

Model 1: Series_Complete_Pop_Pct ~ pct_shift_dem_2016_to_2020
Model 2: Series_Complete_Pop_Pct ~ pct_shift_dem_2016_to_2020 + educ_perc_bachelor_or_higher +
    poverty_perc + household_income_median_log + gender_male_perc +
    age_65plus_perc
  Res.Df    RSS Df Sum of Sq      F    Pr(>F)
1   3111 486546
2   3106 368945  5    117602 198.01 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

We verify that adding covariates in LM Fit 2B produced a better informed model than LM Fit 2A using ANOVA. We see the p-value of < 2.2e-16, statistically significant at the 0.05 level.

Conclusion

In LM Fit 1B, we observed that even after adjusting for confounding factors in county demographics, educational attainment, and poverty/household income level, we still see a statistically significant positive association between Vaccination Rates and Democrat Vote % in 2020. This result supports our hypothesis that public health pandemic response policies in the U.S. likely became a political issue. We leveraged vaccination rates and 2020 election votes as indicative measures of the actions of Americans at the county level to support this.

Interestingly, in LM Fit 2B, we observed that after adjusting for confounding factors in county demographics, educational attainment, and poverty/household income level, the previously statistically significant positive association of Vaccination Rates with Percent Shift in Democrat Vote in 2020 from 2016 turned into a statistically significant negative relationship. This appears to suggest that any shifts between party votes in 2016 and 2020 did not necessarily follow our supposed hypothesis that increasingly *more* left-leaning counties would have higher vaccination rates, but rather supports our original hypothesis stated above, that left-leaning counties in 2020 would be more vaccinated.

This could be the result of many factors that we were not able to control for in the study. One major factor, for example, is that the Democratic candidate was different in 2020 than 2016, while the Republic candidate remained the same. Additionally, American attitudes towards either major party sometimes oscillate depending whichever party was just in office.

If the data were available, it would be highly interesting to do this analysis at the individual American level instead of at the county aggregation level, but this is likely not possible. It'll also be interesting to perform this analysis at the end of next year or even following the next election cycle. How the U.S. recovers from the pandemic and how the current administration is perceived to have performed may also help or hinder future vaccination rates and votes.

References

[1] Baccini, L., Brodeur, A. & Weymouth, S. The COVID-19 pandemic and the 2020 US presidential election. J Popul Econ 34, 739–767 (2021). https://doi.org/10.1007/s00148-020-00820-3.

[2] FDA News Release. FDA Takes Key Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for First COVID-19 Vaccine. 2020. https://www.fda.gov/news-events/press-announcements/fda-takes-key-action-fight-against-covid-19-issuing-emergency-use-authorization-first-covid-19.

[3] Lukpat, A. The U.S. is falling to the lowest vaccination rates of the world's wealthiest democracies. 2021. https://www.nytimes.com/2021/09/11/world/asia/us-vaccination-rate-low.html.

[4] Wikipedia. FIPS County Code. 2021. https://en.wikipedia.org/wiki/FIPS_county_code.

[5] CDC. COVID-19 Vaccinations in the United States,County. 2021. https://data.cdc.gov/Vaccinations/COVID-19-Vaccinations-in-the-United-States-County/8xkx-amqh.

[6] CDC. CDC Expands COVID-19 Booster Recommendations. 2021. https://www.cdc.gov/media/releases/2021/s1129-booster-recommendations.html.

[7] MIT Election Data and Science Lab, 2018, "County Presidential Election Returns 2000-2020", https://doi.org/10.7910/DVN/VOQCHQ, Harvard Dataverse, V9, UNF:6:qSwUYo7FKxI6vd/3Xev2Ng== [fileUNF].

[8] Killeen, B., Wu, J.Y., Shah, K., Zapaishchykova, A., Nikutta, P., Tamhane, A., Chakraborty, S., Wei, J., Gao, T., Thies, M., & Unberath, M. (2020). A County-level Dataset for Informing the United States' Response to COVID-19. ArXiv, abs/2004.00756.