The Effect of Covid-19 Vaccination Lotteries on Percent of the Over 18 Population Vaccinated

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Abstract

This paper considers the effect of state-administered Covid-19 vaccination lotteries on the percent of the over 18 population with at least the first dose of the vaccine. State-administered Covid-19 vaccine lotteries were put in place by many state governments to incentivize vaccination uptake and included cash prizes for select recipients of the vaccine before the end of the incentive period. I estimate the effects of the Covid-19 vaccine lotteries using the difference-in-difference methodology with the treatment group being states with Covid-19 lotteries and the control group being states without Covid-19 lotteries. Having a vaccination lottery is predicted to increase the percent of the over 18 population vaccinated with one dose of the vaccine by 1.27 percentage points more than states without Covid-19 lotteries.

Introduction

Covid-19 or the Coronavirus has caused a public health crisis since its first arrival in the United States in April of 2021. As of November 24th, 2021, 776,000 people have died from Covid-19 in the United States. The highly contagious and deadly nature of the virus has caused varied approaches in containing the viral spread including “lock down”, forced remote work, remote schooling, social distancing, travel control, and mandated quarantines. These methods reduce rates of transmission by relying on individuals to change their behaviors to be more isolated affecting quality of life.

On December 11th, 2020, Pfizer-BioNTech made the first Covid-19 vaccine available to individuals 16 or older. The Covid-19 vaccine was the first method of containing the spread of the virus that was not related to individual lifestyle adjustments. The vaccines has been proven to reduce serious illness such as death and reduce the chances of contracting the disease. Despite the lifesaving properties of the vaccines, many individuals have been hesitant or refuse to receive the vaccine due to religious obligations, and skepticism about the vaccine’s benefits and development.

Up until April 16th the United States saw a steady increase in the number of new reported administered doses per day as reported by the New York Times. After April 16th vaccination, rates showed a steady decline and the number of newly administered vaccines, despite vaccination rates still being relatively low (<60 percent for adults), and death from the virus still a being a significant risk. For context, the Covid-19 vaccine was not available to all Americans over the age of 18 until May 1st and some of decline in the number of new vaccines administered is likely since there were less people eligible to get vaccinated. Today about 85% of the total over 18 US population is vaccinated with at least one dose of the vaccine and 15% remain totally unvaccinated. Out of the population that remain unvaccinated 49.6% say that they are concerned about possible side effects, 42.4% say they don't trust the vaccines, and 35.4% say they don't trust the government. Only 1.7% say that it was difficult to obtain a Covid-19 vaccine. Vaccine distrust and skepticism is a demand side vaccination issue while inability to access a vaccine would be a supply side issue. The survey results would suggest that supply side incentives are likely not going to increase vaccination rates.

The United States has used supply side vaccination incentives to encourage Covid-19 vaccination uptake including making the vaccine free, setting up additional high volume vaccination sites, and offering assisted transportation to vaccination locations. Ohio was the first state to experiment with the use of a conditional cash transfer lottery, a demand side incentive, to increase vaccination rates. The campaign was unique because it attempted to increase vaccination rates by appealing to adding perceived benefit of the vaccine rather than minimizing the cost of obtaining the vaccine. In Ohio the campaign included a randomly selected vaccine recipient would receive up to a $1 million prize or a four-year college scholarship to any public Ohio university, if the recipient was under 18. Covid-19 lotteries have since been adopted by 12 other states.

This paper estimates the effect of state administered Covid-19 vaccine lotteries on the percent of the population with at least one dose of the vaccine based on the jurisdiction where the recipient lives. The paper additionally estimates if the effect differs along two dimensions. Firstly, does the effect of the campaign change based on if the state is primarily democratic or republican as determined by the percent of the population who voted for Joe Biden in the 2020 election. Secondly, does the size of the state lottery change the effectiveness of the policy. It is important to look at if the effects are different for states with different political tendencies because vaccination behavior was heavily politicalized with Republicans being more skeptical of the vaccine which has led to different baseline amounts of the population vaccinated. Determining if the program is more effective based on the incentive's size has public policy implications, since incentive programs are costly at the expense of other public works. If large programs do not significantly impact the effectiveness of the lottery, then governments can at least choose to use a less costly version of the demand side incentive. Finally, if the overall the benefit, increasing vaccination rates, is marginal, governments should engage in other ways to promote public health. My research would lend incite on the effectiveness of using monetary demand side incentives to increase vaccination rates in the United States.

I take advantage of publicly available data on Covid-19 vaccination take up at the state level for all states in the US and the District of Columbia. I exploit the geographical and time variation in vaccination lottery roll across states to estimate the effect of the lotteries on percent of the over 18 population vaccinated using a state and time fixed effect model that is similar to a difference-in-difference estimator. Due to issues in recording second doses of a vaccine, the outcome variable is the percent of the population 18 or older with at least one dose based on the state where the recipient lives. I examine the effect of the lottery two week prior to the lottery start, during the lottery, and then after the lottery. The regression compares the difference between the percent of the over 18 population receiving their first dose of the vaccine after the in the treatment and the control groups over the various time periods to determine the effect of the policy.

Walkey et al. (2021), Barber and West (2021), and Brehm et al. (2021) all recently researched the effect of Ohio's "Vax-a-Million" vaccine campaign on Covid-19 vaccination rates. Previous papers have compared states without Covid-19 lotteries to Ohio, the state with the first Covid-19 lottery. My contributions to the existing literature will include increasing the number of treatment states to 13. By looking at all states with Covid-19 lotteries I will ensure that results are not unique to Ohio. Additionally, using multiple treatment states will allow me to measure heterogeneity of effects between states with the lottery.

Literature Review

The research in this paper on the effects of demand side vaccination incentives on Covid-19 vaccination rates, relates to a broader category of research on the effect of demand side incentives for promoting higher health standards in developing countries (Barham and Maluccio, 2009; Barham et al., 2007; Morris et al., 2004). Conditional Cash Transfer programs like Red de Protección Social in rural Nicaragua paid all participating mothers a set amount of cash if they achieved four health related standards, including vaccinating their children. The findings in the literature suggest that demand side incentives like conditional cash transfer programs increase vaccination rates in the major preventable childhood diseases. The effects are larger for families that have lower income, lower levels of education, or are farther away from vaccination sites. The key differences between the conditional cash transfer programs in South America and the vaccination lotteries in the United States are: (1) they are incentivizing vaccinations for the major early childhood diseases rather than Covid-19, (2) the incentive is guaranteed and given to all participants if they meet the criteria of the program, and (3) the programs target extremely rural and low-income communities.

I broadened my literature review to examine the nature and effects of vaccination campaigns in the United States (Cawley et al. 2010; Unti et al. 2009). Unti (2009) examines school-based vaccination programs effect on Hepatitis B vaccination rates. To participate students needed to have parents sign a form verifying that they could be vaccinated to receive the incentive of the free vaccine provided by the school, scholastic credit, and material rewards in the form of free entry to school social events. Similarly, Cawley (2010) examines the effectiveness of school provided influenza vaccination programs on influenza vaccination rates. Both authors found that providing vaccines to students at school increased vaccination rates in the participating classes and suggest that an individual's decision to get vaccinated can change. The United States has typically taken a supply side approach to vaccination campaigns. While Unti (2009) examines an incentive program that involves providing students access to school events for free which is a demand side policy, the primary incentive is that students can get vaccinated at school; appealing to convivence is an example of a supply side incentive. There is no literature available on just demand side vaccination incentives in the United States prior to the Covid-19 vaccine lotteries.

The three most closely related papers to my analysis are Walkey et al. (2021), Barber and West (2021), and Brehm et al. (2021). All these papers look at the effect of Ohio's Vax-A-Million campaign on Covid-19 vaccination rates. Walkey et al. (2021) used an interrupted time series study using autoregressive segmented regression to evaluate trends in daily adult vaccination rates per 100,000 persons from April 15- May 12, 2021, before the vaccine campaigns announcement, and May 13- June 9, 2021, after the campaigns announcement. Brehm et al. (2021) also analyzed Ohio's "Vax-a-Million" lottery but did so by using the difference-in-difference method comparing vaccination rates before and after the lottery announcement with Ohio as the treatment group and a synthetic Ohio as the control group. The synthetic Ohio which was created using the ridge augmented synthetic control method. Barber and West (2021) also used the difference-in-difference method but constructed the control group using the states bordering Ohio. I will also be using the difference-in-difference methodology but will be comparing states with lottery incentives to states without lottery incentives.

My contributions to the existing literature include increasing the sample size of the treatment group to ensure that any measurable effect is not unique to Ohio and examining if there is heterogeneity in the effect of the policy based on if the state is a blue state or a red state, the size of the monetary incentive, or the relative size of the monetary incentive.

Data and Descriptive Statistics

Data

To determine the effect of the Covid-19 vaccination lottery incentive on vaccination behavior I use the dataset called "COVID-19 Vaccinations in the United States, Jurisdiction" which is available from the CDC website. The dataset has information on the number of administered vaccines in each of the 50 states and the District of Colombia, on each day, between December 14th, 2020, to October 19th, 2021. The data is at the state-day level data. I aggregated the data to the week level help deal with weekday fluctuations. Information on whether a state had a Covid-19 vaccination lottery came from the state's department of public health website; 13 out of the 50 states and DC had vaccination lotteries. I used data from the New York Times on the 2020 election called, "An Extremely Detailed Report of the 2020 Election," to identify state's predominant political affiliation.

I also used IPUMs demographic data collected in 2020 including sex, race, educational attainment, total personal income, and population size to examine baseline state characteristics between states with and without the lottery. An assumption of the difference-in-difference method is that the treatment and control group would have similar or parallel trends had the treatment group never been treated. This is not a testable assumption; however, I use the demographic data to examine if basic state characteristics (many of which don't vary quickly over time) that may be correlated with vaccination take up behavior are similar between the vaccine lottery and non-vaccine lottery state prior to the intervention. I also examine trends in in vaccination take-up prior to the start of the lotteries in my main regression.

Outcome Variable

The key dependent variable, "V_{sw}" , is the percent of the total population over 18 with at least one dose of the vaccine based on the state or jurisdiction in which they live. I restrict the analysis to the percent of the population with the first administered dose, due to data constraints, and since my research question is attempting to understand how the Covid-19 vaccine lottery encourages individuals to obtain any vaccination, rather than incentivizing individual's to be fully vaccinated.

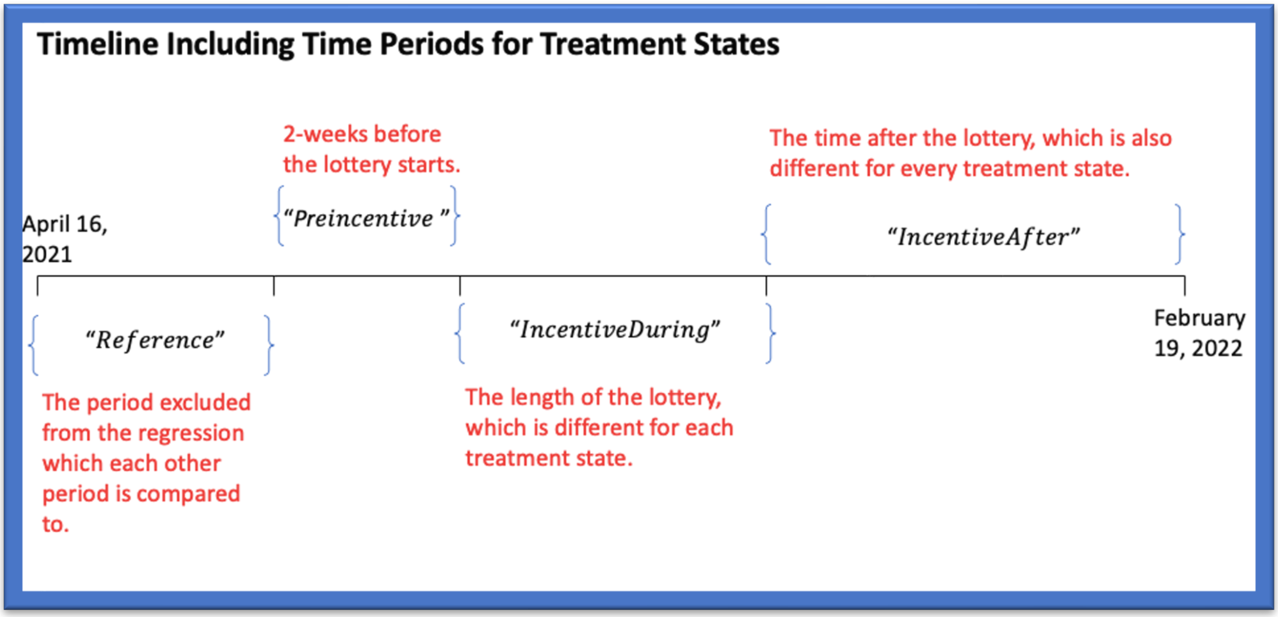
Independent Variables

The main independent variable is an indicator if state, s, had a vaccination lottery at week, w or not. Table 1 lists each of the states with a lottery, the population of the state, the size of the lottery, and lottery's start and end dates. I refer to states that had a cash lottery for vaccination as treatment states, and those that do not, as control states. I examine the effect of the lottery or the incentive in three different time periods, the pre-incentive, during, and after the lottery as displayed in Figure 1. The indicator variable "$Preincentive_{sw}$" equals to 1 if state, *s,* has a Covid-19 lottery and week, *w,* is two weeks before the rollout of the first Covid-19 incentive, and zero otherwise. "$Incentive\ During_{sw}$" equal to 1 if state, *s*, has a Covid-19 lottery and week, *w,* is between the week the lottery is announced and the last week of the lottery incentive, and zero otherwise. "$Incentive\ After_{sw}$" is an indicator variable equal to 1 if state, s, has a Covid-19 lottery and week, w, is after the lottery period. Since there was a staggard rollout of vaccination lotteries, each of the timelines for the individual treatment states will vary but will include these four periods.

Table 1: Summary of Treatment Group

State	Start Date	End Date	Population Size 2021	Total Monetary Cash Prize
Ohio	5/21/21	6/28/21	11,693,217	$4,000,000
Maryland	6/14/21	7/31/21	6,055,802	$2,000,000
Oregon	7/21/21	9/20/21	4,241,507	$1,360,000
Colorado	5/25/21	7/4/21	5,807,719	$5,000,000
California	6/4/21	7/13/21	39,368,078	$116,500,000
Massachusetts	6/4/21	9/27/21	6,893,574	$5,000,000
Washington	5/18/21	6/23/21	7,693,612	$2,000,000
Kentucky	6/30/21	8/3/21	4,477,251	$3,000,000
New Mexico	5/25/21	6/7/21	2,106,319	$10,000,000
Louisiana	5/15/21	8/19/21	4,645,318	$1,400,000
Michigan	7/8/21	8/26/21	9,966,555	$4,650,000
Illinois	6/8/21	8/6/21	12,587,530	$7,000,000
Missouri	5/27/21	7/18/21	6,151,548	$1,800,000

Figure 1: Timeline of Three Incentive Periods



I explore the heterogeneity of the effects on two dimensions. First, I examine political affiliation using the binary indicator variable, "$Blue_s$" that is equal to 1 if state, s, predominately voted for Joe Biden in the 2020 Presidential election, and zero otherwise. Second, I explore if the size of the lottery affects vaccination take up. To compare large lotteries to small lotteries, I define a variable "$Large_s$" to equal 1 if state, s, has a Covid-19 vaccine lottery with a total monetary prize value greater than or equal to 4 million dollars and a zero otherwise. 4 million dollars was chosen as the cut off to determine if a lottery was large, since it is the median total prize amount administered by the 13 lottery states. Since the chance of receiving the lottery may affect people's incentive to get a new vaccine, I also examine the monetary price per capita. The variable "$Rellarge_s$" is an indicator variable equal to 1 if state, s, has a Covid-19 vaccine lottery and the total monetary prize divided by the population size is above 0.46, the median value for the total monetary prize divided by population size.

Figure 2 shows the relationship between the mean percent of the over eighteen population with at least one dose. The green line represents this relationship for states with vaccination lotteries (treatment group), and the orange line represents the relationship for states without vaccination lotteries (control group). The two vertical black lines indicate the period where the vaccination lotteries took place in all the states. The first lottery in Ohio starting at the first black line and the last lottery in Missouri ending at the second black line. Without controls, the treatment states seem to have higher percentages of the population over eighteen with at least one dose vaccinated compared to the control group.

Figure 2: Percent of Population Over 18 with 1st dose of the Vaccine by Treatment Status

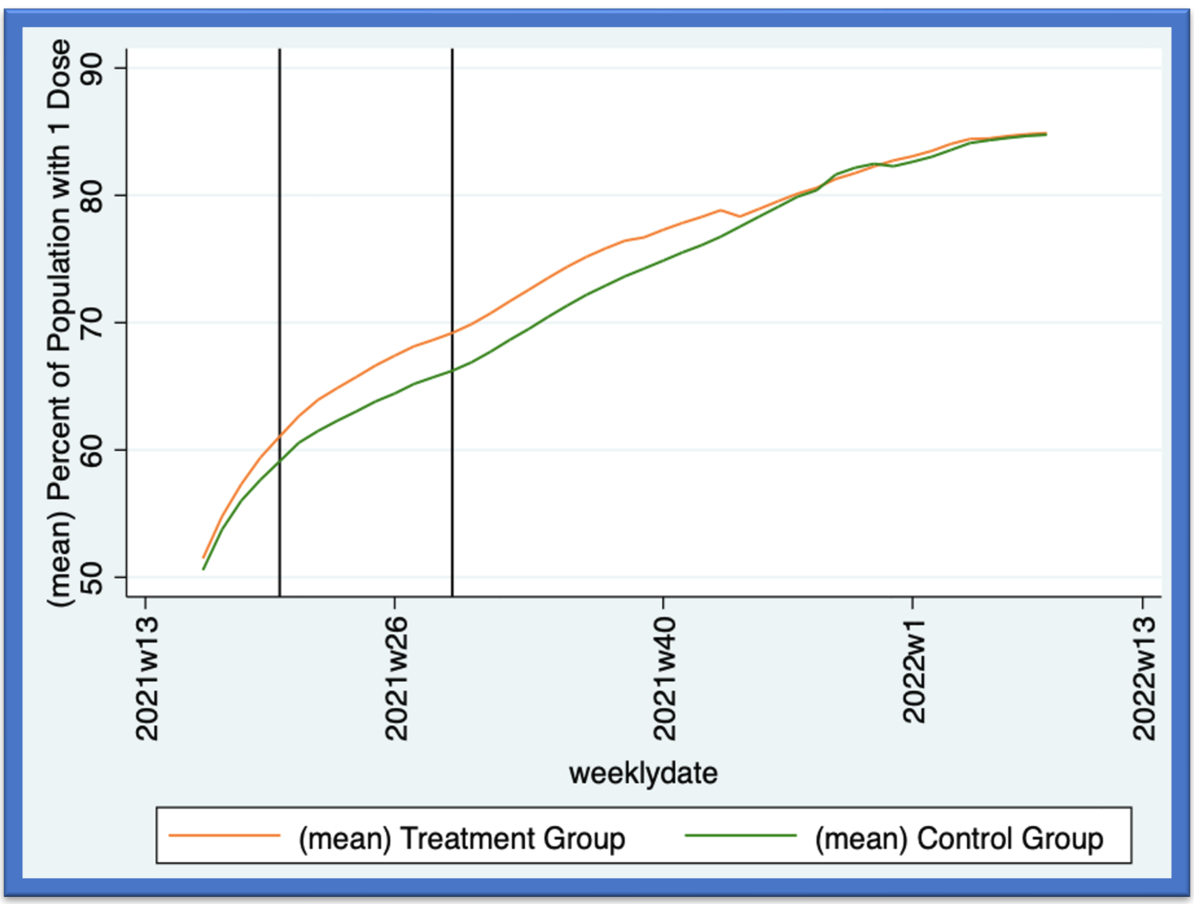
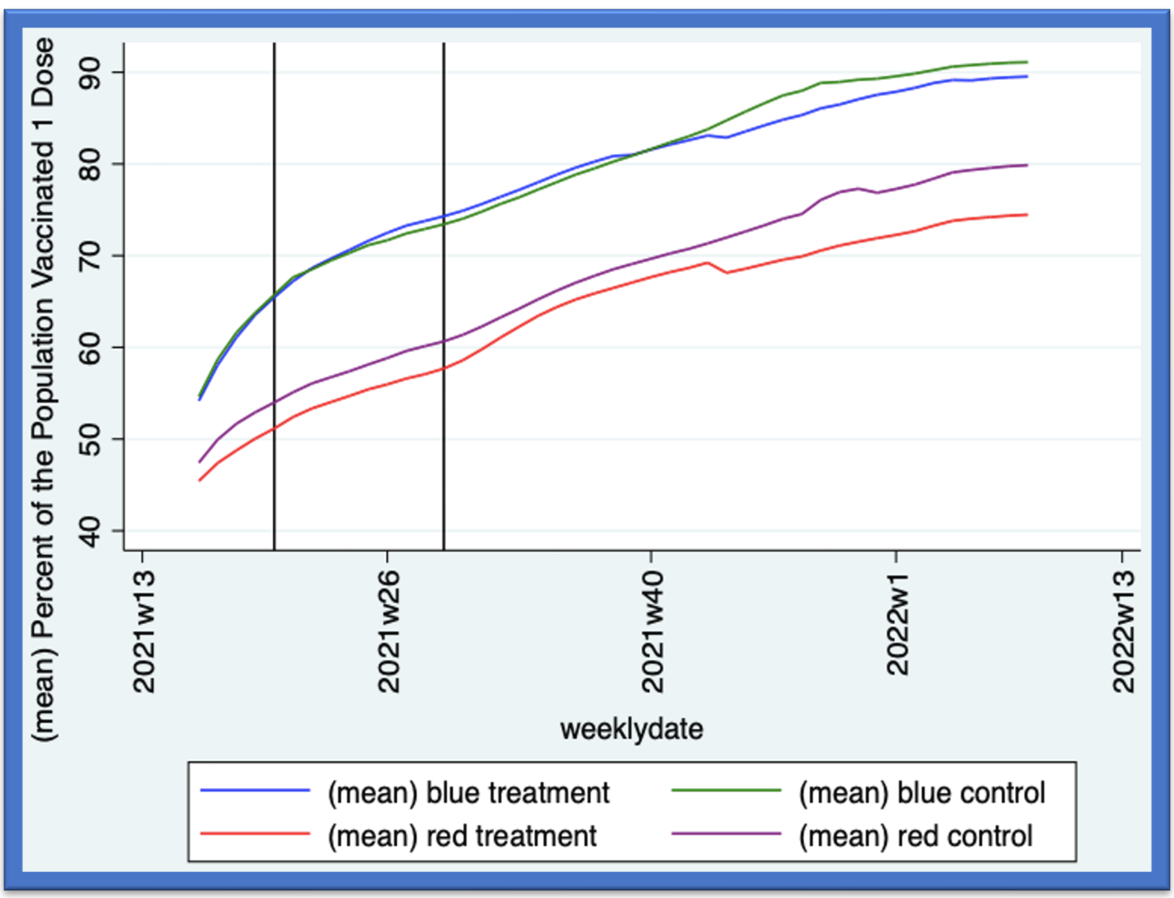


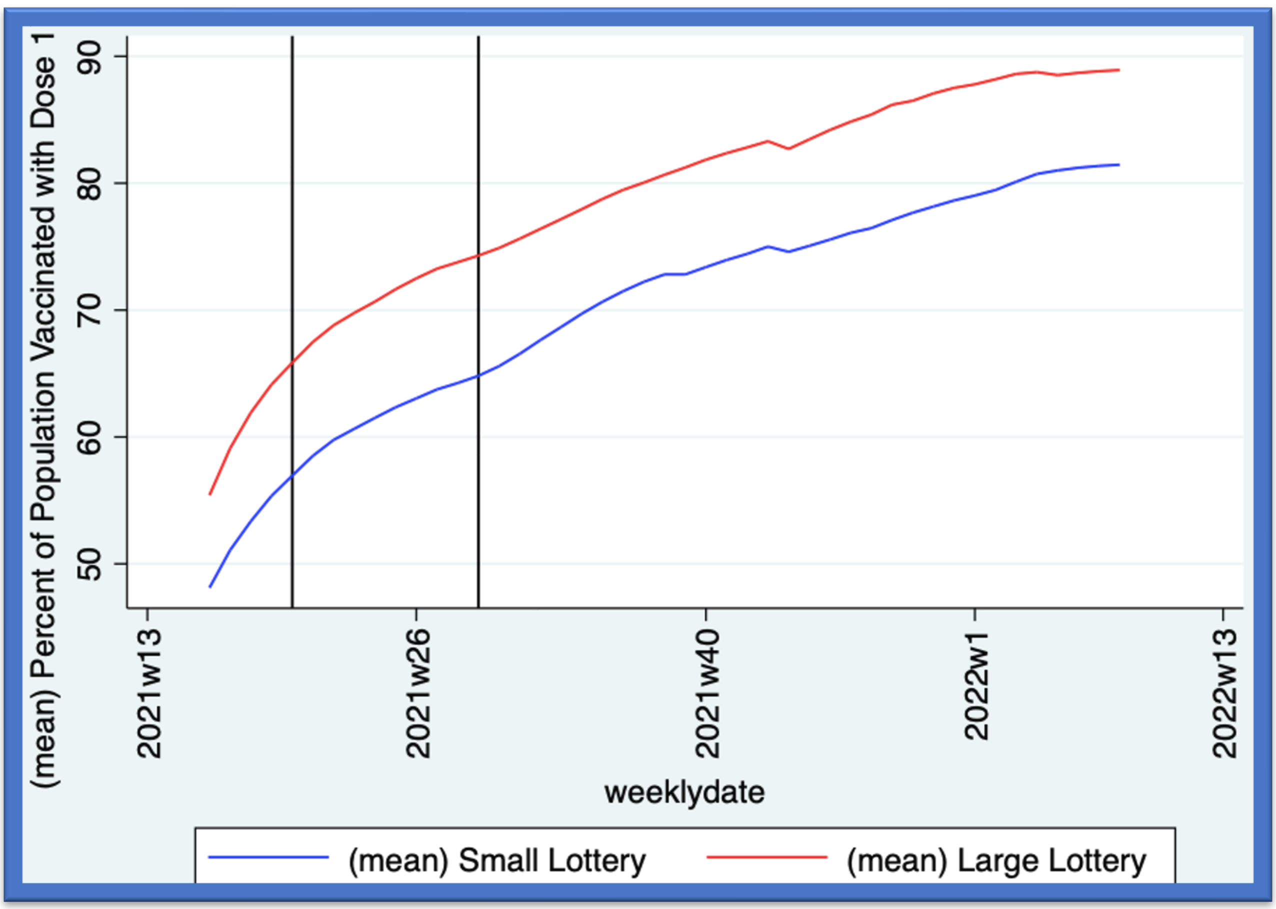
Figure 3 shows the relationship between the mean percentage of the over twelve population with at least one dose within the treatment group for states that are predominately democratic and republican, and in the control group for states that are predominately democratic and republican. The blue line represents this relationship for states that are democratic and in the treatment group, and the red line represents the relationship for states that are republican and in the treatment group. The green line represents the relationship for states that are democratic and in the control group, and the purple line represents the relationship for states that are republican and in the control group. The two vertical black lines still indicate the period where the vaccination lotteries took place. Without controls, democratic states have higher percentages of the population vaccinated compared to republican states.

Figure 3: Percent of the Population Over 18 with 1st dose of the Vaccine by Political Affiliation and Treatment Status



Finally Figure 4 shows the relationship between the mean percent of the over eighteen population with at least one dose for states with large lottery incentives, more than 4 million dollars or more, and states with small lottery incentives, less than four million dollars. The blue line represents states with small lottery incentives, and the red line represents states with large lottery incentives. The two vertical black lines indicate the period where the vaccination lotteries took place in all the states. There trends are very similar between states.

Figure 4: Percent of the Over 18 Population with 1st dose by States with Large Lotteries Compared to Small Lotteries



Controls

I include controls for non-time varying state unobservable variables by including state fixed effects. In addition, I control for any weekly time effects that are common across all states with and weekly fixed effects.

Identification

I exploit variation over time and states in the roll out of the vaccination lotteries to estimate the effect of the lotteries on the percent of the population over 18 getting vaccinated using state and time fixed effect model for state, *s*, in week, *w*. The following is my primary difference-in-difference regression specification.

(1) $V_{sw} = \beta_1\, Preincentive_{sw} + \beta_2\, Incentive\ During_{sw} + \beta_3\, Incentive\ After_{sw} + \nu_s + \lambda_w + \varepsilon_{sw}.$

The betas measure the effect of the vaccine lottery at three points in time. β_1 for the pre-incentive period which compares the percent of the population vaccinated in the two weeks before the lottery to the percent of the population vaccinated in the reference period in the treatment group and subtracts that from the percent of the population vaccinated in the control group. β_2, is the effect of the lottery while the lottery is running. β_3 examines if the effect of the lottery was reduced in the time after the lottery ended.

A key assumption of the difference-in-difference method is that the trends in the outcome variable would have been the same between the treatment (states with lotteries) and control group (states without lotteries), had the treatment group had not been treated. For my research, this means that the trends in the percent of the over 18 population vaccinated would be identical if the treated states or the states with the Covid-19 lotteries were never treated. Since this is not a testable assumption, I use two methods to examine the plausibility of the identification assumption. First, I analyze demographic characteristics to see how similar the treatment and control groups are to each other in terms of factors that are associated with vaccination behavior. Secondly, I will look at a double difference estimator of the pre-incentive period, β_1 , to determine if there were significant and large differences in vaccination behavior before the control and treatment groups. If β_1 is small in magnitude, then the control group and the treatment group have similar vaccination trends in the two weeks leading up to the vaccination incentive. If β_1 is large in magnitude and significant then it is not assumed that the pre-trends in the vaccination behavior between the control group and the treatment group are similar. State trends can be included in the regression to account for differences in the control group and the treatment group's general vaccination behavior. I discuss the pre-trends in the result section.

Rather than looking at the control group and the treatment group and seeing if the vaccination trends look similar prior to the vaccination campaign to determine the plausibility of the identification assumption, researchers can create a synthetic control group based off the characteristics of the treatment group. The method is called propensity score matching (PSM) and provides more plausibility that the trends are similar prior to the intervention. Using this method, I would match each state in the treatment group with a non-treated state with similar characteristics and trends in vaccination behavior. To use PSM, it would be helpful if I had more data on state characteristics and vaccination trends to determine which states would be the best matches.

Baseline Balance

I examine how similar the states are on the characteristics that may influence vaccination behavior. These characteristics include race, educational attainment, yearly income, proportion of the state voting for Joe Biden in the 2020 presidential election, and population size. The summary statistics reported for each individual state are in the Appendix. I examine the difference in each of the characteristics between lottery and non-lottery states using the following regression.

(1) $Characteristics_s = \beta_0 + \beta_1\ Lottery_s$

β_1 can be interpreted as the difference between the means of the control group and the treatment group. β_0 , or the constant, is the mean of the control group or states without vaccination lotteries.

Table 2: Difference in Means of State Characteristics.

VARIABLES	(1) Male	(2) White	(3) Black	(4) High-Education	(5) Income
Lottery	0.00371***	-0.0286***	-0.0304***	0.0136***	2,774***
	(0.000632)	(0.000527)	(0.000392)	(0.000628)	(92.18)
Constant	0.493***	0.787***	0.120***	0.440***	43,843***
	(0.000393)	(0.000327)	(0.000244)	(0.000390)	(57.24)
Observations	2,641,054	2,641,054	2,641,054	2,641,054	2,231,773
R-squared	0.000	0.001	0.002	0.000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To interpret the results for higher education, states without Covid-19 vaccine lotteries had 44% of the population obtain higher education, or education post high school. States with Covid-19 vaccine lotteries had about 45% of the population obtain higher education. Therefore, the difference in means is 1.36 percentage points. The difference is significant at the 0.01 level suggesting that for treatment and control group educational attainment is sufficiently different. The high levels of statistical significance reflect the large sample size of over 2.6 million observations. The magnitude of this difference seems quite small in percentage terms, 1.3 percentage points, and perhaps not large enough to lead to a large change in take-up of the vaccine. The characteristics seem similar results for all the demographic categories, except for perhaps income. Based off this initial analysis alone, the treatment group and the control group having different demographic characteristics that influence vaccination behavior signals that state trends may need to be accounted for in my analysis. If I had more time, I would like to have included statistics on vaccination rates since they would be the best indication of if vaccination behavior in the treatment and control groups were similar prior to the lottery intervention. In addition, I could look at the means divided by the standard deviation to get a better idea of the size of the magnitudes.

Heterogeneity of Effects

The following regression is used to estimate the difference in the effect of the lottery if states are primarily republican compared to states that are primarily democratic.

$$(2)\ V_{sw} = \beta_1\ Incentive\ Before_{sw} + \beta_2\ (Incentive\ Before_{sw} * Blue_s) + \beta_3\ Incentive\ During_{sw} + \beta_4 (Incentive\ During_{sw} * Blue_s) + \beta_5\ Incentive\ After_{sw} + \beta_6 (Incentive\ After_{sw} * Blue_s) + \nu_s + \lambda_w + \varepsilon_{sw}$$

The previous regression analyzed β_1 to see if vaccination trends between the control group and the treatment group were similar in the two weeks prior to the vaccination incentive.

In this specification β_1 will be analyzed to see if vaccination trends between republican states and democratic states were different prior to the incentive. β_3 measures the effect of the lottery for republican states. β_4 measures the predicted percentage point increase of the over 18 population vaccinated in blue states compared to red states under the lottery incentive.

The following regression is used to estimate the difference in the effect of the lottery depending on if the lottery's total monetary value is greater than or equal to 4,000,000, a large lottery, or less than or equal to 4,000,000, a small lottery. 4,000,000 is the median value of the lottery for states with monetary incentives.

$$(3)\ \ V_{sw} = \beta_1\, Incentive\ Before_{sw} + \beta_2\, (Incentive\ Before_{sw} * Large_s) + \beta_3\, Incentive\ During_{sw} + \beta_4 (Incentive\ During_{sw} * Large_s) + \beta_5\, Incentive\ After_{sw} + \beta_6 (Incentive\ After_{sw} * Large_s) + \nu_s + \lambda_w + \varepsilon_{sw}$$

β_1 will still be analyzed to see if vaccination trends in the control group and the treatment group were similar. β_3 measures the effect of the lottery for states had small lotteries. β_4 measures the predicted percentage point increase of the over 18 population vaccinated in states with large lotteries compared to states with small lotteries. The same specification will be analyzed comparing the states with the relatively large vaccination lotteries, these were the vaccination lotteries that when the total monetary prize was divided by the size of the population was above the median value.

Results

Table 3 presents the effects of the vaccine lotteries on the percent of the over 18 population vaccinated with at least one dose of the vaccine in the four different regression specifications. The first model (1) used a basic difference-in-difference regression looking at the effect of the incentive program. The second (2), third (3), and fourth (4) specifications examines the heterogeneity of effects for states based on their political affiliation, the total size of the lottery incentive, and the relative size of the lottery incentive compared to the state's population.

Table 3: Effects of Vaccine Incentive on the Percent of population 18 Plus who Received their First Dose.

VARIABLES	(1) Vsw	(2) Vsw	(3) Vsw	(4) Vsw
Pre-Incentive	0.364	0.414	0.293	0.731
	(0.513)	(0.497)	(0.824)	(0.861)
During Incentive	1.274	1.139**	1.568	1.521
	(0.769)	(0.545)	(0.976)	(1.095)
After Incentive	-0.266	-0.549	0.855	0.894
	(1.102)	(1.455)	(1.152)	(1.142)
Pre-Incentive: Blue		-0.750		
		(0.908)		
During Incentive: Blue		-0.895		
		(1.249)		
After Incentive: Blue		-0.507		
		(2.017)		
Pre-Incentive: Large			0.0577	
			(0.975)	
During Incentive: Large			-0.577	
			(1.292)	
After Incentive: Large			-2.136	
			(1.675)	
Pre-Incentive: Relatively Large				-0.616
				(0.989)
During Incentive: Relatively Large				-0.501
				(1.364)
After Incentive: Relatively Large				-2.102
				(1.637)
Constant	46.42***	48.88***	46.41***	46.43***
	(0.726)	(0.803)	(0.723)	(0.725)
Observations	16,120	16,120	16,120	16,120
R-squared	0.963	0.965	0.963	0.963

State FE	YES	YES	YES	YES
Weekly FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In each of the models the pre-incentive period, two weeks before the lottery incentive starts, examines if the trends between the lottery and non-lottery states are similar prior to the rollout of the lottery campaign. If vaccination behavior before the lottery incentive was different between the treatment and control group, then it is important that the difference in vaccination trends is controlled for. Since all the coefficients were small in magnitude, state trends were not included in any of the regressions.

Results from the first regression, show that two weeks prior to the lottery incentive treatment states had 0.36 percentage points more of the over 18 population with the first dose of the vaccine compared to the control group. Since the estimate is not significant and small the pre-vaccination trends between the control group and the treatment group are similar enough that difference in vaccination trends was not controlled for. From the first regression its predicted that for states with a Covid-19 vaccine lottery the percent of the over 18 population with the first dose of the vaccine is 1.27 percentage points more than states without a Covid-19 vaccination lottery. The results are not significant at the 10% level.

The second model examines if the effects of the lottery are heterogenous for states that are predominately republican compared to states that are primarily democratic. For republican states with a Covid-19 vaccination lottery is predicted to increase the percentage of the over 18 population vaccinated by 1.13 percentage points. These results are statistically significant at the 5% level. Having a Covid-19 vaccination lottery is predicted to increase percentage of the over 18 population vaccinated by 0.56 percentage points less for blue states compared to red states.

Therefore, the effect of the lottery is 0.22 percentage points for blue states which is positive but very small. These results indicate that having a Covid-19 vaccine is more effective in republican states than democratic states.

The third regression demonstrates if the size of the total monetary reward changes effectiveness of the lottery incentive. For small lottery incentives the Covid-19 vaccination lottery is predicted to increase percentage of the over 18 population vaccinated by 1.568 percentage points. Having a Covid-19 lottery is predicted to increase the percentage of the over 18 population vaccinated by 0.57 percentage points less where the total monetary incentive was more than 4 million dollars compared to states where the lottery incentive was less than 4 million dollars. The results are not significant at the ten percent level.

Finally, the last regression is analyzed to determine if the effectiveness of the lottery incentive changes based on the size of the total monetary rewards adjusted for the state's population size. I divided the total monetary reward by the size of the state population in 2020. For relatively small incentives the Covid-19 vaccination lottery is predicted to increase the percentage of the over 18 population vaccinated by 1.521 percentage points. Having a Covid-19 lottery is predicted to increase the percentage of the over 18 population vaccinated by 0.50 percentage points less for relatively big lotteries than relatively small lotteries. While these results were similar to the results found when lottery size was looked at without accounting for population size, neither of the estimates indicate conclusive findings about the impact of having a large or a small lottery. The results may indicate that individuals do not closely consider the size of their population in comparison to the total monetary value of the lottery incentive when making the decision to get vaccinated. All the estimates were insignificant at the 10% level of significance.

Discussion

My research confirms the findings of Barber and West (2021) who found similar results when looking at the effect of the Covid-19 vaccine lotteries on the percentage of the population vaccinated. Barber and West analyzed Ohio's Covid-19 vaccination lottery to a synthetic control constructed with the states surrounding Ohio, which is a very similar method to the one that I used. They found that the vaccinated share of the state population increased by 0.7 percentage points in Ohio compared to the other surrounding control states.

Effectiveness of the Covid-19 vaccinations have policy implications for the use demand side vaccination incentives in the United States. My analysis indicates that the Covid-19 vaccine campaigns did increase the percent of the state population over 18 vaccinated particularly in Republican states, where vaccination hesitancy was more prominent. This demonstrates that individual's vaccination behavior can change in response to a demand side incentive. On May 26th, 2021, the federal government announced that states could use the federal government aid and the trillion-dollar relief package passed earlier that month to fund Covid-19 vaccine lotteries like Ohio. For vaccines like the flu or early childhood vaccines local governments are not receiving large amounts of money for vaccination campaigns, therefore states would have to fund similar campaigns using state resources. Large demand side incentives are more feasible during a public health crisis when monetary funds can be quickly generated for relief, collective action by the public is necessary, and the cost of contamination is high. Since the increase in the percent of the population vaccinated is small and insignificant, demand side conditional cash transfers should be carefully considered before being used as a public health intervention.

Shortcomings on my analysis include using the regular double difference method to calculate my findings rather than the newly developed staggard difference-in-difference method and the existing bias of variables that may vary by state and time that could be correlated with the rollout of the vaccination incentive.

The staggard difference-in-difference method was developed because the standard two-way fixed effects approach does not adequately measure coefficients when the treatment effect is heterogeneous across time or units. A problem with the regular difference-in-difference method is that treatment states act as control states in all the time periods that the incentive is not occurring. The way I have coded my variables, I do not have problems with treatment states getting coded into the control group in periods where they are not experiencing the treatment. On the other hand, I do have heterogeneity of effects across time. I would like to read in detail about how the a staggard model could improve my estimates for this reason.

Finally, the difference-in-difference method does not control for variables that vary by state and time that could be correlated with the roll out of vaccination incentives. For example, if Kentucky decided to have a Covid-19 vaccination campaign in response to hospitals running out of ICU beds, then I expect more people to get vaccinated knowing that there is more risk associated with getting very sick. In this scenario the double difference estimator cannot differentiate the individuals getting vaccinated because the increased risk of inadequate care associated with overfilled hospitals, from the individuals getting vaccinated because of the recently administered Covid-19 vaccine campaign. The double difference estimator will therefore overestimate the effect of intervention. Other events that would cause a positive bias include the state administered vaccine education campaigns that were rolled out at the same time as the vaccination lottery. Events with a negative bias include a group of individuals having adverse reactions to the vaccine at a state-administered Covid-19 vaccination site leading the governor to administer the Covid-19 vaccination lottery to increase vaccination rate. In this scenario in the state where the group of adverse reactions occurred the vaccinate rate may drop since individual's may be increasing fearful of getting the vaccine, and therefore lead to underestimates of the effect of the Covid-19 vaccination policy overall.

Appendix

Table 4: State Summary Statistics

Treatment Group

State (FIPS code)	Percent Male	Percent White	Percent Black	Percent Higher-Ed	Mean Income	Percent of Votes for Biden	Population Size
California	49.94%	59.19%	6.23%	46.99%	50980.97	63.50%	39,368,078
Colorado	50.66%	87.13%	4.46%	51.94%	51876.60	55.40%	5,807,719
Illinois	49.44%	78.87%	11.03%	45.60%	47197.86	57.50%	12,587,530
Kentucky	49.52%	90.50%	7.61%	38.31%	37337.05	36.20%	4,477,251
Louisiana	48.87%	68.02%	28.76%	37.99%	37537.67	39.90%	4,645,318
Maryland	48.39%	63.11%	26.57%	49.26%	56920.33	65.40%	6,055,802
Massachusetts	48.54%	81.98%	7.69%	52.98%	56170.76	65.60%	6,893,574
Michigan	49.70%	86.13%	9.79%	43.62%	40609.52	50.60%	9,966,555
Missouri	49.49%	88.07%	9.11%	40.50%	38990.89	41.40%	6,151,548
New Mexico	49.69%	69.29%	3.14%	44.31%	36105.29	54.30%	2,106,319
Ohio	49.08%	87.38%	10.58%	40.42%	40404.09	45.20%	11,693,217
Oregon	49.46%	88.80%	2.41%	48.69%	44959.75	56.50%	4,241,507
Washington	49.61%	80.50%	4.28%	49.66%	53066.22	58.00%	7,693,612

Control Group

State (FIPS code)	Percent Male	Percent White	Percent Black	Percent Higher-Ed	Mean Income	Percent of Votes for Biden	Population Size
Alabama	48.41%	74.07%	23.42%	40.03%	36445.80	36.60%	4,921,532
Alaska	53.39%	65.17%	2.82%	37.14%	44392.95	42.80%	731,158
Arizona	49.93%	77.25%	5.23%	45.91%	42108.89	49.36%	7,421,401
Arkansas	49.22%	82.07%	13.75%	35.50%	33559.68	34.80%	3,030,522
Connecticut	48.52%	80.76%	10.27%	49.91%	58030.95	59.30%	3,557,006
Delaware	48.49%	75.55%	18.08%	45.88%	47346.75	58.80%	986,809
District of Columbia	47.46%	57.38%	35.50%	62.83%	76957.60	92.10%	712,816
Florida	49.04%	78.41%	14.61%	46.26%	43263.38	47.90%	21,733,312
Georgia	49.10%	66.05%	27.50%	43.24%	41916.05	49.47%	10,710,017
Hawaii	49.42%	43.34%	2.90%	46.47%	45784.95	63.70%	1,407,006
Idaho	49.90%	91.60%	1.10%	42.06%	37289.81	33.10%	1,826,913

Indiana	49.50%	89.44%	7.48%	37.98%	37562.98	41.00%	6,754,953
Iowa	49.68%	94.11%	3.38%	41.00%	38762.86	44.90%	3,163,561
Kansas	50.07%	90.30%	5.00%	43.43%	40025.30	41.50%	2,913,805
Kentucky	49.52%	90.50%	7.61%	38.31%	37337.05	36.20%	4,477,251
Maine	49.84%	96.35%	1.74%	45.87%	38554.53	51.30%	1,350,141
Minnesota	50.79%	91.65%	3.68%	46.07%	46224.56	52.40%	5,657,342
Mississippi	48.51%	61.94%	35.92%	38.70%	30827.88	41.00%	2,966,786
Montana	50.32%	89.94%	0.87%	44.04%	38771.88	40.50%	1,080,577
Nebraska	49.74%	91.10%	3.75%	43.47%	41759.16	39.20%	1,937,552
Nevada	49.90%	69.45%	9.62%	41.35%	42496.62	50.10%	3,138,259
New Hampshire	49.54%	94.92%	2.54%	50.25%	49837.95	52.70%	1,366,275
New Jersey	48.65%	70.27%	12.76%	48.30%	56277.19	57.10%	8,882,371
New York	48.60%	69.40%	14.32%	46.58%	48348.07	60.90%	19,336,776
North Carolina	48.85%	74.24%	19.23%	46.12%	40930.37	48.60%	10,600,823
North Dakota	51.87%	91.36%	2.11%	44.04%	44774.25	31.80%	765,309
Oklahoma	49.77%	78.42%	7.71%	35.84%	34105.97	32.30%	3,980,783
Pennsylvania	49.33%	88.41%	7.84%	40.70%	42816.57	50.00%	12,783,254
Rhode Island	48.04%	83.89%	8.11%	47.63%	44728.90	59.40%	1,057,125
South Carolina	48.76%	73.76%	22.85%	43.89%	38787.54	43.40%	5,218,040
South Dakota	50.35%	85.64%	1.63%	39.60%	38314.71	35.60%	892,717
Tennessee	49.05%	82.94%	13.79%	39.82%	38567.47	37.50%	6,886,834
Texas	49.90%	75.04%	11.08%	42.32%	43204.50	46.50%	29,360,759
Utah	49.89%	90.68%	1.81%	44.73%	42756.41	37.60%	3,249,879
Vermont	49.34%	96.31%	1.44%	50.33%	42997.52	66.10%	623,347
Virginia	49.18%	73.57%	17.80%	49.09%	53083.44	54.10%	8,590,563
West Virginia	49.48%	94.57%	4.65%	34.31%	32546.97	29.70%	1,784,787
Wisconsin	50.44%	92.24%	4.38%	42.07%	41481.59	49.45%	5,832,655
Wyoming	50.39%	90.99%	1.14%	42.49%	42196.43	26.60%	582,328

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