Promoting Vaccination Uptake: A Simulated Randomized Trail of Social Media Intervention

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I. Introduction

Previous studies have indicated that conducting research in controlled groups was effective for studying how social media interventions impact vaccination attitudes and intentions [1-5]. This study aimed to find out if ads intervention on Facebook could increase vaccination uptake. I conducted an analysis on simulated survey data from randomly assigned treatment and control groups. There were two types of ads in my study: reason and emotion. The reason ad presented scientific information about the virus and immunization rates, while the emotion ad aimed to highlight the prospect of closer relationships after vaccination.

I simulated the data based on the survey questions and assumptions listed in Appendix 2. (I assumed that the study took place on Jan 1st 2022 when people started concerning whether they should get a 2nd dose of vaccination, and the ad intervention lasted for three months.) At step one, I recruited 5,000 Facebook user across US, with the 50 states and 1 special territory as clusters. At step two, each participant in the survey was randomly assigned to one of three groups: 1/3 received the first ad (reason), 1/3 received the first ad (emotion), and 1/3 received no ad (control group). The survey was conducted at two time points: Jan 1st 2022 (Baseline) and Mar 31st 2022 (Endline). The survey contained questions on Covid-19 vaccination status, attitudes towards vaccination, attitudes towards social media, party affiliation and demographic controls. Ultimately, 4,500 individuals responded to the final survey.

The primary outcome of the study was the the self-reported vaccine uptake among participants. In the survey, I asked the participants: have you received a COVID-19 vaccine? The uptake was equal to 1 when respondent answered 'yes' or 'no, but I made an appointment'. The uptake was equal to 0 when respondent answered 'no'. I used logistic regression to test whether our ad intervention impacted vaccine uptake. In the analysis of the impact of ads below, I used pre- and post-intervention vaccination uptake data to calculate estimates. These estimates were based on a difference-in-difference (DiD) specification in equation below

$$logit(y_{igt}) = \alpha + \beta_g D_{ig} + \gamma \text{ Post }_{it} + \delta_g D_{ig} \times \text{ Post }_{it} + \varepsilon_{igt} \tag{1}$$

where $logit(y_{igt})$ represents the log-odds of the binary outcome variable being 1, D_{ig} was a dummy variable equal to 1 if participant i is in treatment group g, and $Post_{it}$ is a dummy equal to 1 if the observation for participant i was after the adoption of the intervention. The coefficient of interest, δ_g, measured the extent to which the outcome $logit(y_{igt})$ for participant i in the post period differed from the expected level, given its baseline level. DiD relied on the assumption that, in the absence of the ads, the treatment group (reason or emotion ads) would have the same mean change in the vaccine uptakes as the control group (no ad). Our balance test in Table 3 proved that there was no difference between the treatment group and control group.

II. Research Questions

1. Can the Facebook ad campaigns increase COVID-19 vaccination uptake?

2. Which is more effective in promoting vaccination: reason-based advertisements or emotion-based advertisements?

3. Do varying advertisements demonstrate effectiveness with specific target demographics in promoting vaccination?

III. Results

3.1 Balance Test

The balance test in Table 3 reported comparisons of participates in control group and two treatment groups. It showed that, in general, the randomization assignment balanced these groups on observed vaccination status and intention, attitudes towards COVID, attitudes towards social media, party affiliation, and demographics.

3.2 Main Results

A significant value of the coefficient, δ_g, for the interaction term ($D_{ig} \times$ Post $_{it}$) would indicate a differential change in vaccination uptake between the treatment and control group. Table 4 showed that the odds of being vaccinated for the treatment group compared to the control group are 1.467 times higher in the post-treatment period compared to the pre-treatment period, on average. Furthermore, Tables 5 and 6 shed light on the varying impact of emotional and rational ads. In Tables 5 and 6, I found that emotional ads had a stronger influence compared to rational ads, on average. Specifically, when it came to getting vaccinated, the odds of individuals in the emotional ads group, compared to the control group, were 1.395 times higher in the period after the treatment (post-treatment) compared to before the treatment (pre-treatment). Similarly, for the rational ads group, the odds of being vaccinated compared to the control group are 1.543 times higher in the post-treatment period compared to the pre-treatment period. Overall, the ad intervention, especially for emotion ad seemed quite effective in promoting vaccination uptake.

3.3 Heterogeneity Analysis

Would the impact of advertising intervention be different among participants with different party affiliation, education and age? To test these, I ran separate regressions for different groups of people.

I discovered that people in both republics and democracies were notably affected by advertisements when it came to getting vaccinated, particularly emotional ads. However, the impact was a bit stronger for republic groups compared to democracy groups. This aligned with the vaccination rates reported through news[1] during that time.

The regression results from Tables 8 and 9 reveal distinct impacts of emotional and rational ad appeals across educational groups, particularly influencing individuals with lower levels of education. For those with a high school education or some college experience, the ads intervention significantly increased their vaccination uptake. However, individuals with bachelor's and postgraduate degrees showed positive coefficients, yet they did not reach statistical significance at the 95% confidence level. But, I was uncertain if this was influenced by the limited number of samples from individuals with higher education levels.

Tables 10 and 11 demonstrate variations in the impact of emotional and rational ads among different age groups. Emotional ads had a more pronounced effect on individuals aged 25-55, while rational ads appeared to be more impactful for those aged 45 and above. This may be attributed to individuals between 25 and 55 resonating more with emotional appeals, potentially influenced by family responsibilities, career objectives, and personal relationships. In contrast, individuals aged 45 and above seemed to prioritize rational considerations, such as health and long-term planning.

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[1]For COVID-19 vaccinations, party affiliation matters more than race and ethnicity

IV. Discussion and Conclusion

Promoting vaccination uptake was a core objective for health organizations during the pandemic. The analysis, conducted on a simulated data set, revealed that emotion-based and reason-based ads on social media can increase vaccination uptakes. To determine participants for the intervention, we conducted randomization, ensuring a balance between treatment and control groups across Covid-19 vaccination status, attitudes towards vaccination, attitudes towards social media, party affiliation, and demographic controls. The results underscored that individuals with diverse political affiliations, educational backgrounds, and ages may be influenced in distinct ways. Therefore, in practical applications, it would be advisable to tailor ad designs more specifically to target different groups of people.

References

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Appendix

A1: Tables and Graphics in the Report

A2: Survey Questions and Simulation Assumptions
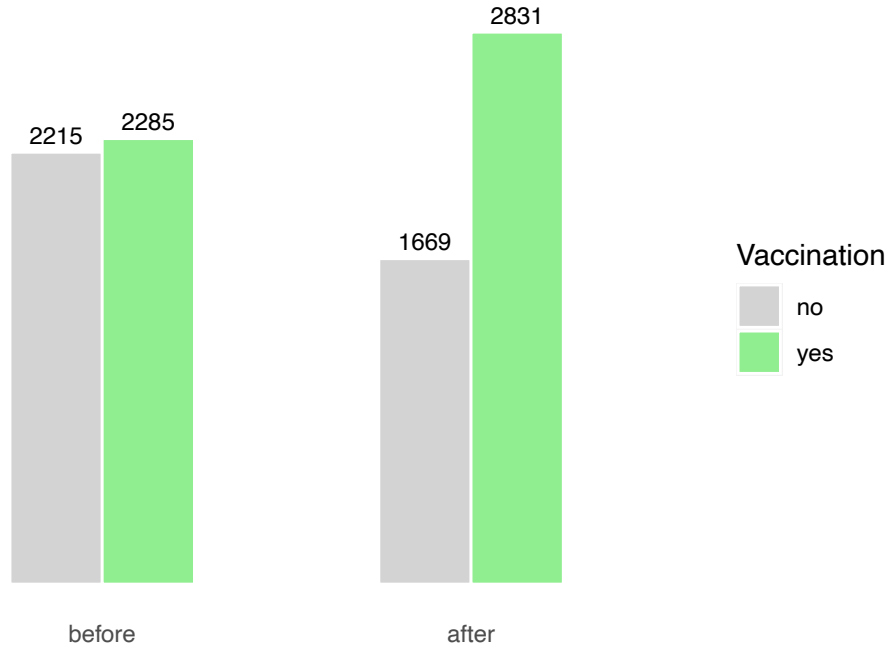
Appendix 1: Tables and Graphics

Figure 1: Vaccination uptake before and after intervention

Table 1: Treatment Assignment and Retention

Group	Phase.1	Phase.2	Retension
Control	1667	1514	0.9
Reason	1657	1493	0.9
Emotion	1676	1493	0.9
Total	5000	4500	0.9

Table 2: Summary Statistics in Baseline Survey

Statistic	Mean	St. Dev.	Median	Min	Max	N
uptake	0.507	0.500	1	0	1	5,000
likely	2.974	1.430	3	1	5	5,000
worry	3.025	1.398	3	1	5	5,000
safe	3.000	1.405	3	1	5	5,000
imp	3.013	1.425	3	1	5	5,000
family	3.041	1.413	3	1	5	5,000
belief	2.993	1.410	3	1	5	5,000
republic	0.496	0.500	0	0	1	5,000
male	0.496	0.500	0	0	1	5,000
urban	0.503	0.500	1	0	1	5,000
race_white	0.645	0.479	1	0	1	5,000
race_black	0.152	0.359	0	0	1	5,000
race_hispanic	0.103	0.304	0	0	1	5,000
race_asian	0.060	0.237	0	0	1	5,000
age_15-24	0.243	0.429	0	0	1	5,000
age_25-34	0.254	0.435	0	0	1	5,000
age_35-44	0.149	0.356	0	0	1	5,000
age_45-54	0.151	0.358	0	0	1	5,000
age_55-64	0.152	0.359	0	0	1	5,000
age_others	0.052	0.222	0	0	1	5,000
edu_high_school	0.360	0.480	0	0	1	5,000
edu_some_college	0.254	0.435	0	0	1	5,000
edu_bachelor	0.139	0.346	0	0	1	5,000
edu_postgraduate	0.053	0.223	0	0	1	5,000
edu_others	0.195	0.396	0	0	1	5,000
occ_management_and_professional	0.295	0.456	0	0	1	5,000
occ_service	0.206	0.404	0	0	1	5,000
occ_sales_and_office	0.299	0.458	0	0	1	5,000
occ_farming_fishing_and_forestry	0.048	0.214	0	0	1	5,000
occ_construction_extraction_and_maintenance	0.103	0.303	0	0	1	5,000
occ_others	0.049	0.216	0	0	1	5,000
work_home	0.201	0.401	0	0	1	5,000
work_onsite	0.501	0.500	1	0	1	5,000
work_hybrid	0.298	0.458	0	0	1	5,000

Table 3: Balance Test

variables	Control	Treatment		P-value		
	control	emotion	reason	con.vs.emo	con.vs.rea	emo.vs.rea
Vaccination status and intention						
uptake	0.509	0.498	0.5160	0.549	0.686	0.317
likely	3.009	2.968	2.9390	0.435	0.177	0.574
Attitudes towards covid						
worry	3.021	3.026	3.0310	0.930	0.843	0.913
safe	2.997	2.999	3.0140	0.959	0.736	0.776
imp	3.034	3.005	2.9970	0.577	0.477	0.876
family	3.087	3.029	3.0150	0.264	0.163	0.779
Attitudes towards social media						
belief	2.949	3.038	2.9780	0.082	0.595	0.237
Party affiliation						
republic	0.495	0.480	0.5080	0.424	0.466	0.128
Demographic controls						
male	0.479	0.499	0.4950	0.287	0.384	0.843
urban	0.513	0.491	0.5060	0.236	0.691	0.431
race_white	0.636	0.640	0.6500	0.826	0.400	0.537
race_black	0.167	0.157	0.1400	0.428	0.040	0.209
race_hispanic	0.102	0.105	0.1070	0.801	0.641	0.832
race_asian	0.052	0.059	0.0660	0.438	0.114	0.424
edu_high_school	0.354	0.364	0.3610	0.591	0.680	0.899
edu_some_college	0.260	0.236	0.2630	0.135	0.833	0.089
edu_bachelor	0.135	0.144	0.1340	0.450	0.961	0.422
edu_postgraduate	0.051	0.059	0.0500	0.309	0.894	0.251
'age_15-24'	0.244	0.235	0.2460	0.561	0.900	0.481
'age_25-34'	0.255	0.256	0.2530	0.936	0.901	0.838
'age_35-44'	0.151	0.153	0.1430	0.890	0.510	0.428
'age_45-44'	0.143	0.159	0.1460	0.227	0.830	0.321
'age_55-64'	0.152	0.147	0.1570	0.706	0.679	0.430
occ_management_and_professional	0.303	0.310	0.2720	0.678	0.066	0.025
occ_service	0.204	0.192	0.0193	0.387	0.214	0.129
occ_sales_and_office	0.288	0.294	0.3210	0.747	0.051	0.105
occ_farming_fishing_and_forestry	0.043	0.049	0.0520	0.412	0.252	0.749
occ_construction_extraction_and_maintenance	0.102	0.109	0.0980	0.582	0.662	0.325
work_home	0.204	0.199	0.1980	0.758	0.703	0.943
work_onsite	0.500	0.514	0.4850	0.449	0.401	0.117

* Column 1-3 show mean, column 4-6 report the p-value of the test of equality of means of control group v.s. emotion group, control group v.s. reason group, emotion group v.s. reason group.

† All the variables are from answers to the questions in our survey.

‡ P-value larger than 0.05 means that we cannot reject the null hypothesis that there is no significant difference between the means of the two groups being compared. We find that most variables are balanced, except in two t-tests. The race_black variable in the control and reason groups, and the occ_management_and_professional variable in the emotion and reason groups, are significant at a 95% confidence level but not significant at a 99% confidence level. Overall, we find there is no significant difference between the means of the compared two groups.

Table 4: Facebook ads intervention and self-reported Covid-19 vaccination uptake

	uptake		
	(1)	(2)	(3)
treatment:time	0.386***	0.386***	0.383***
	(0.062)	(0.062)	(0.062)
treatment	−0.007	−0.006	−0.005
	(0.044)	(0.044)	(0.044)
time	−0.057	−0.057	−0.054
	(0.052)	(0.052)	(0.052)
worry			−0.019*
			(0.010)
safe			0.014
			(0.010)
imp			0.016
			(0.010)
family			0.035***
			(0.010)
belief			0.021**
			(0.010)
republic			−0.065**
			(0.028)
Demographic controls	No	Yes	Yes
StateFE	Yes	Yes	Yes
N	9,000	9,000	9,000
R^2	0.015	0.017	0.020
Max. Possible R^2	0.997	0.997	0.997
Log Likelihood	−26,420.450	−26,415.720	−26,400.970
Wald Test	143.500*** (df = 3)	153.010*** (df = 25)	182.500*** (df = 31)
LR Test	140.311*** (df = 3)	149.776*** (df = 25)	179.283*** (df = 31)
Score (Logrank) Test	144.895*** (df = 3)	154.408*** (df = 25)	183.913*** (df = 31)

Notes: This will be replaced

Table 5: Reason ads intervention and self-reported Covid-19 vaccination uptake

	Dependent variable:		
	uptake		
	(1)	(2)	(3)
group_reason:time	0.338***	0.338***	0.333***
	(0.070)	(0.070)	(0.070)
group_reason	0.009	0.009	0.013
	(0.051)	(0.051)	(0.051)
time	−0.057	−0.057	−0.054
	(0.052)	(0.052)	(0.052)
worry			−0.017
			(0.012)
safe			0.013
			(0.012)
imp			0.020
			(0.012)
family			0.037***
			(0.012)
belief			0.019
			(0.012)
republic			−0.069**
			(0.035)
Demographic controls	No	Yes	Yes
StateFE	Yes	Yes	Yes
Observations	6,036	6,036	6,036
R^2	0.011	0.013	0.016
Max. Possible R^2	0.995	0.995	0.995
Log Likelihood	−15,761.930	−15,756.520	−15,746.410
Wald Test	67.620*** (df = 3)	78.410*** (df = 25)	98.530*** (df = 31)
LR Test	65.177*** (df = 3)	75.994*** (df = 25)	96.225*** (df = 31)
Score (Logrank) Test	68.157*** (df = 3)	78.951*** (df = 25)	99.094*** (df = 31)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6: Emotion ads intervention and self-reported Covid-19 vaccination uptake

	Dependent variable:		
	uptake		
	(1)	(2)	(3)
group_emotion:time	0.434***	0.434***	0.434***
	(0.070)	(0.070)	(0.070)
group_emotion	−0.027	−0.026	−0.028
	(0.052)	(0.052)	(0.052)
time	−0.057	−0.057	−0.056
	(0.052)	(0.052)	(0.052)
worry			−0.021*
			(0.012)
safe			0.015
			(0.012)
imp			0.012
			(0.012)
family			0.032***
			(0.012)
belief			0.029**
			(0.012)
republic			−0.071**
			(0.035)
Demographic controls	No	Yes	Yes
StateFE	Yes	Yes	Yes
Observations	5,990	5,990	5,990
R^2	0.016	0.018	0.021
Max. Possible R^2	0.995	0.995	0.995
Log Likelihood	−15,751.580	−15,747.350	−15,736.760
Wald Test	103.530*** (df = 3)	112.010*** (df = 25)	133.140*** (df = 31)
LR Test	98.907*** (df = 3)	107.367*** (df = 25)	128.541*** (df = 31)
Score (Logrank) Test	104.760*** (df = 3)	113.238*** (df = 25)	134.397*** (df = 31)

Note: *p<0.1; **p<0.05; ***p<0.01

Table 7: Ads intervention and vaccination uptake by party affiliation

	Dependent variable:			
	uptake Democracy	uptake Democracy	uptake Republic	uptake Republic
	(1)	(2)	(3)	(4)
group_emotion:time	0.376*** (0.097)		0.499*** (0.103)	
group_reason:time		0.266*** (0.098)		0.407*** (0.101)
group_emotion	−0.012 (0.073)		−0.044 (0.075)	
group_reason		0.028 (0.073)		−0.006 (0.073)
worry	−0.014 (0.017)	−0.012 (0.017)	−0.031* (0.018)	−0.021 (0.018)
safe	0.005 (0.017)	0.021 (0.018)	0.030* (0.018)	0.005 (0.018)
imp	0.021 (0.017)	0.016 (0.017)	0.003 (0.018)	0.026 (0.018)
family	0.022 (0.017)	0.041** (0.017)	0.046** (0.018)	0.035* (0.018)
belief	0.021 (0.017)	0.023 (0.017)	0.039** (0.018)	0.015 (0.018)
time	0.032 (0.071)	0.036 (0.071)	−0.157** (0.076)	−0.152** (0.075)
Demographic controls	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	3,068	3,008	2,922	3,028
R^2	0.023	0.017	0.024	0.018
Max. Possible R^2	0.991	0.990	0.987	0.987
Log Likelihood	−7,210.069	−6,943.417	−6,267.077	−6,529.832
Wald Test (df = 30)	73.760***	51.730***	72.620***	56.320***
LR Test (df = 30)	71.056***	50.290**	71.242***	56.158***
Score (Logrank) Test (df = 30)	74.520***	52.039***	73.236***	56.688***

Note: *p<0.1; **p<0.05; ***p<0.01

Table 8: Emotional ads intervention and vaccination uptake by education

	Dependent variable:			
	uptake High School	uptake Some college	uptake Bachelor	uptake Postgraduate
	(1)	(2)	(3)	(4)
group_emotion:time	0.470***	0.517***	0.255	0.516*
	(0.117)	(0.143)	(0.187)	(0.296)
group_emotion	−0.045	−0.096	0.001	−0.041
	(0.087)	(0.109)	(0.143)	(0.244)
time	−0.073	−0.134	0.018	−0.258
	(0.086)	(0.102)	(0.140)	(0.229)
worry	−0.037*	−0.033	−0.013	0.045
	(0.021)	(0.026)	(0.033)	(0.055)
safe	0.008	0.029	0.012	0.049
	(0.021)	(0.026)	(0.034)	(0.057)
imp	0.006	−0.016	0.045	0.036
	(0.021)	(0.026)	(0.034)	(0.059)
family	0.025	0.040	0.078**	0.026
	(0.021)	(0.025)	(0.035)	(0.058)
belief	0.023	0.045*	0.065*	−0.021
	(0.021)	(0.026)	(0.035)	(0.061)
Demographic controls	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	2,150	1,486	836	330
R^2	0.023	0.027	0.029	0.043
Max. Possible R^2	0.986	0.974	0.961	0.911
Log Likelihood	−4,528.245	−2,699.816	−1,345.409	−391.400
Wald Test (df = 27)	51.020***	41.730**	24.530	14.040
LR Test (df = 27)	49.398***	41.204**	24.614	14.513
Score (Logrank) Test (df = 27)	51.520***	42.015**	24.680	14.304

Note: *p<0.1; **p<0.05; ***p<0.01

Table 9: Reason ads intervention and vaccination uptake by education

		Dependent variable:		
	uptake High School	uptake Some college	uptake Bachelor	uptake Postgraduate
	(1)	(2)	(3)	(4)
group_reason:time	0.360***	0.413***	0.344*	0.368
	(0.118)	(0.138)	(0.192)	(0.311)
group_reason	−0.053	−0.007	−0.039	0.096
	(0.086)	(0.100)	(0.148)	(0.254)
time	−0.074	−0.125	0.025	−0.265
	(0.086)	(0.102)	(0.140)	(0.230)
worry	−0.028	−0.029	−0.002	0.050
	(0.021)	(0.025)	(0.036)	(0.062)
safe	−0.004	0.041*	−0.013	0.019
	(0.021)	(0.025)	(0.035)	(0.064)
imp	0.013	0.020	0.042	0.016
	(0.021)	(0.024)	(0.035)	(0.064)
family	0.022	0.036	0.051	0.047
	(0.021)	(0.024)	(0.035)	(0.066)
belief	0.025	0.009	0.035	0.049
	(0.021)	(0.024)	(0.036)	(0.061)
Demographic controls	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	2,160	1,578	812	304
R^2	0.014	0.022	0.028	0.042
Max. Possible R^2	0.983	0.978	0.955	0.886
Log Likelihood	−4,416.113	−2,985.548	−1,249.125	−323.919
Wald Test (df = 27)	31.440	36.180	23.230	12.370
LR Test (df = 27)	30.860	35.789	22.858	12.973
Score (Logrank) Test (df = 27)	31.581	36.424	23.443	12.710

Note: *p<0.1; **p<0.05; ***p<0.01

Table 10: Emotional ads intervention and vaccination uptake by age

	Dependent variable:				
	uptake 15-24	uptake 25-34	uptake 35-44	uptake 45-54	uptake 55-64
	(1)	(2)	(3)	(4)	(5)
group_emotion:time	0.419***	0.495***	0.442**	0.487***	0.385**
	(0.145)	(0.141)	(0.182)	(0.180)	(0.185)
group_emotion	−0.013	−0.001	−0.074	−0.154	0.053
	(0.111)	(0.104)	(0.136)	(0.136)	(0.139)
time	0.001	−0.106	−0.085	−0.092	−0.043
	(0.105)	(0.105)	(0.133)	(0.133)	(0.135)
worry	0.002	−0.033	−0.039	−0.015	−0.018
	(0.026)	(0.025)	(0.033)	(0.033)	(0.033)
safe	0.010	0.004	0.003	0.036	0.037
	(0.026)	(0.025)	(0.033)	(0.033)	(0.034)
imp	0.028	0.015	0.023	0.024	−0.023
	(0.026)	(0.025)	(0.033)	(0.033)	(0.034)
family	0.045*	0.013	0.023	0.044	0.047
	(0.026)	(0.025)	(0.033)	(0.033)	(0.034)
belief	0.043	0.041	0.020	−0.007	0.044
	(0.026)	(0.025)	(0.033)	(0.033)	(0.033)
Demographic controls	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes
Observations	1,434	1,532	912	902	896
R^2	0.030	0.029	0.024	0.024	0.038
Max. Possible R^2	0.975	0.977	0.959	0.964	0.959
Log Likelihood	−2,621.727	−2,855.373	−1,442.458	−1,488.172	−1,412.394
Wald Test (df = 26)	45.360**	46.140***	22.470	22.430	34.690
LR Test (df = 26)	43.988**	44.818**	22.062	22.257	34.318
Score (Logrank) Test (df = 26)	45.787***	46.659***	22.652	22.599	35.059

Note: *p<0.1; **p<0.05; ***p<0.01

Table 11: Reason ads intervention and vaccination uptake by education

	Dependent variable:				
	uptake 15-24	uptake 25-34	uptake 35-44	uptake 45-54	uptake 55-64
	(1)	(2)	(3)	(4)	(5)
group_reason:time	0.329**	0.321**	0.311*	0.401**	0.401**
	(0.142)	(0.142)	(0.182)	(0.184)	(0.180)
group_reason	0.033	0.015	0.043	−0.157	0.089
	(0.107)	(0.104)	(0.137)	(0.139)	(0.136)
time	−0.001	−0.107	−0.082	−0.088	−0.042
	(0.105)	(0.105)	(0.133)	(0.133)	(0.135)
worry	−0.019	−0.042	0.016	0.012	−0.021
	(0.026)	(0.026)	(0.033)	(0.034)	(0.033)
safe	0.017	0.016	−0.014	0.001	0.028
	(0.025)	(0.026)	(0.033)	(0.033)	(0.033)
imp	0.008	0.041	0.047	0.007	−0.032
	(0.026)	(0.025)	(0.033)	(0.035)	(0.033)
family	0.064**	0.009	0.023	0.047	0.051
	(0.025)	(0.026)	(0.034)	(0.033)	(0.033)
belief	0.041	0.019	−0.001	0.003	0.046
	(0.026)	(0.025)	(0.033)	(0.034)	(0.033)
Demographic controls	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes
Observations	1,478	1,534	888	870	934
R^2	0.025	0.018	0.024	0.026	0.038
Max. Possible R^2	0.977	0.973	0.959	0.960	0.962
Log Likelihood	−2,753.342	−2,748.785	−1,412.428	−1,393.631	−1,509.062
Wald Test (df = 26)	38.840*	27.750	21.400	22.900	36.530*
LR Test (df = 26)	38.022*	27.703	21.506	22.981	36.047*
Score (Logrank) Test (df = 26)	39.109**	27.868	21.580	23.095	36.964*

Note: *p<0.1; **p<0.05; ***p<0.01

A1: Survey Questions and Simulation Assumptions

Variable	Question	Answers	Simulation Assumptions
	Vaccination Status and Intention		
uptake	Have you received the COVID–19 vaccine?	– Yes – No, but I have an appointment – No	Baseline: 50% people received covid vaccination. Endline: uptake is influenced by 'treatment group', 'worry', 'safe', 'imp', 'family', 'belief', 'republic'
likely	How likely are you to get the COVID–19 vaccine?	1: Extremely unlikely, 2: Somewhat unlikely, 3:Neither likely nor unlikely, 4: Somewhat likely, 5: extremely likely	Follows a normal distribution.
	Attitude towards COVID–19		
worry	How worried are you about getting COVID–19?	1: Not worried at all, 2: Slightly worried, 3: Somewhat worried, 4: Very worried, 5: Extremely worried	Follows a normal distribution.
safe	How safe do you think the COVID–19 vaccine is for you?	1:Not at all safe, 2: A little safe, 3: Moderately safe , 4:Mostly safe, 5: Very safe	Follows a normal distribution.
imp	How important do you think getting a COVID–19 vaccination was for your health?	1: Not at all important, 2: Slightly important, 3: Moderately important, 4: Very important, 5: Extremely important	Follows a normal distribution.
family	How much do you think getting a COVID–19 vaccine for yourself will	1: None at all, 2: A little, 3: A moderate amount, 4: A lot, 5:A great deal	Follows a normal distribution.

	protect other people in your family and community from COVID-19?		
	Attitudes towards social media		
belief	How much do you belief the information about Covid-19 in social media?	Scale 1–5. 1: Do not believe at all, 3: neutral, 5: I completely believe	Follows a normal distribution.
	Party Affiliation		
republic	Are you republican?	– Yes – No	50% participates are republic
	Demographic Information **(*roughly the same as real US demographic distribution)**		
male	What is your gender?	– Male – Female	50% people is male
state	Where do you live?	Dropdown list of 50 states & 1 District	The sample size of each state is roughly the same
race	What is your race?	– White – Black – Asian – Hispanic – Not listed	– White: 65% – Black: 15% – Asian: 6% – Hispanic: 10% – Not listed: 4%
edu	What is your highest degree?	– High school – Some college – Bachelor – Postgraduate – Not listed	– High school: 35% – Some college: 25% – Bachelor: 15% – Postgraduate: 5% – Not listed:20%
age	How old are you?	– Age 15–24 – Age 25–34 – Age 35–44 – Age 45–54 – Age 55–64	– Age 15–24: 25% – Age 25–34: 25% – Age 35–44: 15% – Age 45–54: 15% – Age 55–64: 15%

		– Not listed	– Not listed: 5%
occ	What is your occupation?	– Management and professional – Service – Sales and office – Farming, fishing and forestry – Construction, extraction and maintenance – Not listed	– Management and professional: 30% – Service: 20% – Sales and office: 30% – Farming, fishing and forestry: 10% – Construction, extraction and maintenance: 5% – Not listed: 5%
work	In which way do you work most of the time?	– I work from home – I work onsite – Hybrid	– I work from home: 20% – I work onsite: 50% – Hybrid: 30%