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The Impact of Large-Scale Social Media Advertising Campaigns on COVID-19 Vaccination: Evidence from Two Randomized Controlled Trials

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Lisa Y. Ho
MIT

Emily Breza
Harvard University

Marcella Alsan
Harvard Kennedy School

Abhijit Banerjee
MIT

Arun G. Chandrasekhar
Stanford University

Fatima Cody Stanford
Massachusetts General Hospital, Harvard Medical School

Renato Fior
Assistance Publique Hôpitaux de Paris

Paul Goldsmith-Pinkham
Yale School of Management

Kelly Holland
Lynn Community Health Center

Emily Hoppe
Johns Hopkins School of Nursing

Louis-Maël Jean
Poverty Action Lab

Lucy Ogbu-Nwobodo
Massachusetts General Hospital

Benjamin A. Olken
MIT

Carlos Torres
Massachusetts General Hospital

Pierre-Luc Vautrey
MIT

Erica Warner
Massachusetts General Hospital

Esther Duflo
MIT

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Lisa Y. Ho, Emily Breza, Marcella Alsan, Abhijit Banerjee, Arun G. Chandrasekhar, Fatima Cody Stanford, Renato Fior, Paul Goldsmith-Pinkham, Kelly Holland, Emily Hoppe, Louis-Maël Jean, Lucy Ogbu-Nwobodo, Benjamin A. Olken, Carlos Torres, Pierre-Luc Vautrey, Erica Warner, and Esther Duflo
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ABSTRACT

COVID-19 vaccines are widely available in wealthy countries, yet many people remain unvaccinated. Understanding the effectiveness -- or lack thereof -- of popular vaccination campaign strategies is therefore critical. In this paper, we report results from two studies that tested strategies central to current vaccination outreach: (1) direct communication by health professionals addressing questions about vaccination and (2) efforts to motivate individuals to promote vaccination within their social networks. Near the peak of the Omicron wave, doctor- and nurse-produced videos were disseminated to 17.8 million Facebook users in the US and 11.5 million in France. In both countries, we cannot reject the null of no effect of any of the interventions on any of the outcome variables (first doses - US and France, second doses and boosters - US). We can reject very small effects on first doses during the interventions in both countries (0.16pp - US, 0.021pp - France). In contrast with similar campaigns earlier in the pandemic to encourage health-preserving behaviors, messaging at this stage of the pandemic -- whether aimed at the unvaccinated or those tasked with encouraging others -- did not change vaccination decisions.

Lisa Y. Ho
MIT
lisaho@mit.edu

Emily Breza
Harvard University
Littauer Center, M28
1805 Cambridge Street
Cambridge, MA 02138
and NBER
ebreza@fas.harvard.edu

Marcella Alsan
Kennedy School of Government
Harvard University
79 John F. Kennedy St.
Rubenstein Bldg R403
and NBER
marcella_alsan@hks.harvard.edu

Abhijit Banerjee
Department of Economics, E52-540
MIT
77 Massachusetts Avenue
Cambridge, MA 02139
and NBER
banerjee@mit.edu

Arun G. Chandrasekhar
Department of Economics
Stanford University
579 Jane Stanford Way
Stanford, CA 94305
and NBER
arungc@stanford.edu

Fatima Cody Stanford
Massachusetts General Hospital
Harvard Medical School
fstanford@mgh.harvard.edu

Renato Fior
Assistance Publique Hôpitaux
de Paris
55 Bd Diderot CS 22305
Paris 75610
France
renato.fior@aphp.fr

Paul Goldsmith-Pinkham
Yale School of Management
165 Whitney Avenue
New Haven, CT 06511
and NBER
paulgp@gmail.com

Kelly Holland
Lynn Community Health Center
269 Union St
Lynn, MA 01901
kholland@lchcnet.org

Emily Hoppe
Johns Hopkins School of Nursing
525 N. Wolfe St.
Baltimore, MD 21205
ehoppe1@jhu.edu

Louis-Maël Jean
lmjean@povertyactionlab.org

Lucy Ogbu-Nwobodo
logbu-nwobodo@mgh.harvard.edu

Benjamin A. Olken
Department of Economics, E52-542
MIT
77 Massachusetts Avenue
Cambridge, MA 02139
and NBER
bolken@mit.edu

Carlos Torres
Massachusetts General Hospital
Harvard Medical School
ctorres4@partners.org

Pierre-Luc Vautrey
MIT
Department of Economics
Building E52-300
50 Memorial Drive
Cambridge, MA 02142
vautrey@mit.edu

Erica Warner
55 Fruit St
Boston, MA 02114
ewarner@mgh.harvard.edu

Esther Duflo
Department of Economics, E52-544
MIT
77 Massachusetts Avenue
Cambridge, MA 02139
and NBER
eduflo@mit.edu

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1. Introduction

Despite widespread availability of COVID-19 vaccinations in wealthy countries, many people remain unvaccinated. In the US, as of August 2022, 68% of adults were fully vaccinated (with two doses) and 32% had received a booster. In France, while the average full vaccination rate is much higher (78% fully vaccinated, 57% boosted), there remain pockets of low vaccination. This is despite very active campaigns to try to encourage vaccination. Understanding why some of the popular strategies to encourage vaccination have worked or not worked remains therefore critical.

Physicians and nurses are among the most trusted experts in the United States and Europe (Altman 2021, Perona, 2020; Harris Interactive 2019). During the COVID-19 crisis many healthcare professionals used social media to spread public health messages. This strategy has been an important part of the effort to promote vaccination. For example, the Kaiser Family Foundation (KFF) sponsored a large project where physicians recorded videos to provide explanations about COVID-19 vaccination and dispel doubts about the vaccine (Altman 2021).

However, some people may be mistrustful of advice coming from experts, and may react better to advice given by laypeople, who are more similar and whose experience may be more relevant. For example, in the case of flu vaccination, an online experiment comparing encouragement by laypeople and medical experts found that the laypeople-promoted treatment led to larger subsequent uptake of the vaccine, even though the laypeople were seen as less competent and trustworthy (Alsan & Eichmeyer 2021). Moreover, the effectiveness of non-expert messengers were driven by those with the least experience with vaccination -- i.e., the holdouts.

Another (potentially complementary) strategy to promote vaccination is therefore to activate local social networks. Previous studies have demonstrated the effectiveness of leveraging social networks and celebrities that can mobilize communities to increase preventative health care measures (Alatas et al. 2019, VanderWeele and Christakis 2019, Banerjee et al 2020, Chevrel & Éveillard 2021). This was an important part of the Biden administration policy for COVID-19 vaccination outreach. Launched in April 2021, the COVID-19 community corps aims to enroll individuals and organizations in vaccine outreach. The web page of the community corps makes resources, including videos and information sheets available to make outreach more effective, and encourages people to sign up to become part of the movement. Nevertheless, it never became a massive enterprise. By May 2022, it had only 17,000 members, which is a very small fraction of the United States.

In previous work, we found empirical evidence that both of these approaches could be promising. First, we found that video messages sent by physicians and nurses had meaningful impacts in terms of improved COVID-19 knowledge (Alsan et al. 2021) and information-seeking and willingness to pay for masks (Torres et al. 2021). Moreover, we found impacts on preventive behaviors: videos sent to millions of Facebook users in fall 2020 to encourage them not to travel for the Thanksgiving and Christmas holidays led to a significant decrease in distance traveled and in subsequent COVID-19 infection (Breza et al. 2021). Second, the strategy to enroll locally influential people to promote childhood vaccination in India seems to have potential. Banerjee et al. (2019) found that the most effective way to identify locally influential people was to simply ask members of their social network who is best suited to circulate information. Then, in villages where such people were reminded approximately once per month to tell their friends and acquaintances that they should get immunized, immunization rates in the village increased (Banerjee et al. 2019, 2021). Studies have also found that other light-touch interventions, such as text messages, can be effective at increasing flu vaccination in the US (Milkman et al. 2021) and non-vaccination preventive health behavior related to COVID-19 in rural areas of India and Bangladesh (Siddique et al. 2020), although elsewhere in India similar text-based nudges were not effective (Bahety et al. 2021).

However, evidence that these strategies are effective to promote COVID-19 vaccination is lacking. In particular, months after the vaccine was introduced, it is not known whether this type of light touch outreach could still persuade the unvaccinated, or if opinions had been sufficiently hardened to be too difficult to change. In the present study, we address this gap by conducting two large scale randomized controlled trials in the US and in France.

In both countries, physicians and nurses recorded short videos to promote COVID-19 vaccination and address common doubts about vaccination. The videos (available on the US study website at https://www.doctorsforcovidprevention.org and on the France study website at https://vaccin-action.org/) addressed, amongst other issues, the nature of the vaccine, the authorization process, the myths surrounding ivermectin, and the efficacy of the vaccine against the Omicron variant.

In December 2021 and January 2022 (US) and February and March 2022 (France), at the height of the COVID-19 Omicron wave, these videos were placed as sponsored messages on Facebook, a platform that 69% of US adults report ever using, half of which do so several times a day (Gramlich, 2022). These messages were shown to Facebook users in randomly selected areas (counties in the US and the equivalent area in France), chosen from a sample of regions and states where vaccination rates were particularly low relative to the rest of the country.

In a second group of areas, Facebook users were shown a doctor- or nurse-recorded video encouraging them to become an immunization ambassador for their friends. The message directed them to a site where they could easily share any of the videos diffused in the first treatment.

In the US only, in a third group of areas, users were encouraged to think about their most influential friend, and to encourage *them* to encourage others to get vaccinated. Finally, in both countries, there was a control group. In total, 17,828,769 Facebook users were shown at least one video in the US, and 11,518,110 were shown a video in France.

Our primary outcome is the number of vaccinations received. In the US, we examine first vaccination, completed sequence, or booster, and in France, for data availability reasons, we focus on first vaccination only. We use administrative data on all vaccinations received at the area level within a given week (or in France, two-week period).

The key result is that in both countries, we fail to reject the null of no impact on any of the treatments on any of the outcomes. At the height of the Omicron wave, it appears that a large-scale social media campaign with a variety of well-produced video messages delivered by physicians and nurses was ineffective in changing minds, and an appeal to people to convince their friends and family was similarly ineffective. This contrasts with other results (including by this team) suggesting that similar light-touch campaigns were effective at earlier points in the pandemic, both in the US and around the world. This suggests that by the winter of 2022, opinions on vaccination were quite firmly held, and difficult to affect through light-touch campaigns.

2. Study design

2.1 Treatments

The treatments were all initiated through Facebook platforms (Facebook and Instagram). Facebook users located in treatment areas were exposed to one of three (US) or one of two (France) ad campaigns featuring a set of videos about COVID-19 vaccination.

In the US, the videos featured doctors and nurses from Massachusetts General Hospital (MGH), Harvard Kennedy School (HKS), Johns Hopkins School of Nursing, Harvard Medical School (HMS), Lynn Community Health Center, St. Anthony North Family Medicine, and McGovern Medical School, and were sent from the Facebook group we created for our previous study, Doctors for Coronavirus Prevention. In France, the videos featured doctors and nurses from "Assistance Publique – Hôpitaux de Paris" (APHP). All of the ads were associated with the project Facebook page titled "Vidéos Réalisées par des Médecins." The videos were short (approximately 30 seconds in length) and professionally produced by Code3 Creative, a digital marketing company (selected and paid for by Facebook). Physicians and nurses were usually wearing scrubs, white coats, or other medical uniforms. All of the videos used in the campaigns can be found https://www.doctorsforcovidprevention.org (US) and https://vaccin-action.org/

(France). The scripts addressed common questions and misconceptions about COVID-19 vaccination, and were produced by members of the study team.

The randomization was done at the area level (county in the US, ZIP code / EPCI in France). Once an area was selected to be in a treatment, the ad campaign was programmed to optimize for the Facebook “reach” objective, with budget allocations roughly proportional to population. The ads were all targeted to Facebook users aged 18 and older. As with any Facebook ad, individuals could choose whether or not to watch the video and could close the ad at any time. If individuals wished, they could also share any of the content with others.

In addition, we commissioned the creation of a website for each country.[1] Individuals interested in learning more could click through a link in the ad to the study website, where they could watch all the videos about vaccination, share these videos with friends, and sign up to be a vaccine ambassador. They could share their contact information with the study as a vaccine ambassador to a) be entered into prize lotteries, b) receive reminders to share content with others, c) be contacted in the future for possible follow-up surveys.

There were three treatment groups in the US and two treatment groups in France, as well as one control group in both countries.

Control group : Facebook users in these areas received no messages from the study.

Treatment Group 1 ("Direct" messaging): The videos about COVID-19 vaccination were directly served to a large number of Facebook users. The rationale for this treatment was two-fold. First, it was very similar to what many groups had done, including the Kaiser Family Foundation (which also had a partnership with Facebook for delivery)[2]. Second, it was very similar in structure to the successful campaign we ran in the fall of 2021, where the same physicians recorded videos delivered via Facebook to encourage limiting travel over the Thanksgiving period.

Treatment Group 2 ("Friends" messaging): For this group, the Facebook ad campaign was a video encouraging viewers to help spread the word about vaccination to their friends (see script below).

Help beat COVID-19. Encourage your friends to get vaccinated! Friends are the best way to convince friends that widespread COVID-19 vaccination is the key to protect ourselves and resume our normal lives. If you want to be part of this movement, click to visit our website. My

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[1] The website link for the US is https://www.doctorsforcovidprevention.org, and the website link for France is https://vaccin-action.org/ . All of the videos used in the campaigns can be found on these websites.

[2] To learn more about this study, visit https://about.fb.com/news/2021/10/supporting-covid-19-vaccine-children/

name is [NAME], and I am a [HEALTHCARE ROLE] at [INSTITUTION]. Each vaccination makes all of US safer. Get your vaccine today.

These ads were disseminated in a similar manner to the content in T1. Individuals were able to easily share the ad with others and those interested in learning more could click through a link in the ad to the study website, where they could watch other videos about vaccination, share these videos with friends, and sign up to be a vaccine ambassador. The rationale was again two-fold. First, this was a cornerstone of the Biden administration strategy. On a website with resources to watch and share, individuals were encouraged to sign up to be part of the "community corps" (the equivalent of our vaccine ambassador). Second, many experts believed that friends would be able to have tailored conversations with vaccine-hesitant friends, and to convince people who would not be convinced by abstract figures (such as unknown doctors). In previous work, some of US (Alsan and Eichmeyer 2021) had found video messages on flu shots by laypeople were more persuasive than the same message recorded by the same people perceived to instead be medical experts. Therefore, it may be more effective to send a message directed to people who are already vaccinated and convinced, and who may be able to convince others. This idea was widely promoted in the media where readers could find tips about how to have these conversations with their friends. Crucially, however, this strategy depends on the willingness of laypeople to sign up for such engagement which might depend on how entrenched views are at the time of the intervention.

Treatment Group 3 (US only) ("Gossips" messaging): Facebook users received ads which encouraged them to ask their most influential friends to encourage their friends to get vaccinated (see script below).

Help beat COVID-19. Encourage your friends to get vaccinated! Do you know people who everyone listens to and want to help as well? Friends are the best way to convince friends that widespread COVID-19 vaccination is the key to protect ourselves and resume our normal lives. If you want to be part of this movement, click to visit our website. Most importantly, share this post with your friends who reach and motivate the most people. My name is [NAME], and I am a [HEALTHCARE ROLE] at [INSTITUTION]. Each vaccination makes all of US safer. Get your vaccine today.

In this treatment, users were encouraged to think about their most influential friends and to share this message which encouraged them to click on the link and think about becoming a vaccine ambassador. This variation on treatment 2 was more novel, and the rationale for this treatment was rooted in our previous work on childhood vaccination in India, where we found that individuals that are nominated by members of their social network (e.g. their village) to be locally influential and best to convey information are much more effective as immunization ambassadors than randomly selected people (Banerjee et al. 2019). We thus hypothesized that if some of the initially targeted Facebook users enrolled their most talkative individuals, the impact on immunization might be larger.

2.2. Sample population and Treatment assignment

United States

The experimental sample includes all states where less than 60% of the total population had received a first dose of COVID-19 vaccine by October 21, 2021. There are 1402 counties in the 19 states satisfying those criteria (Alabama, Alaska, Arkansas, Georgia, Idaho, Iowa, Indiana, Louisiana, Michigan, Mississippi, Missouri, Montana, North Dakota, Ohio, Oklahoma, South Carolina, Tennessee, West Virginia, Wyoming). Excluding the five counties with missing data, there are 1,397 counties in the experiment.

The experimental sample counties were nearly all Republican-leaning. In the 2016 election, 90% of the counties had higher vote shares for the Republican than Democratic party. The sample is also largely rural; 67% of counties are classified as "non-metro" according to the USDA's latest rural-urban continuum codes[3].

Randomization was conducted at the county level (figure 1.a). County-level randomization was stratified by three characteristics: 1) state, 2) political leaning (according to 2016 election results), and 3) baseline vaccination rates. For political leaning, counties were divided into below- and above- median GOP vote in the 2016 presidential election. For baseline vaccination rates, counties were divided into above- and below median percentage of the population that had received the 1st dose of Covid-19 vaccine. After stratifying on these three variables, strata were adjusted so that no stratum was smaller than 9 counties. Strata with fewer than nine counties were dissolved by baseline percentage of population having a first dose of vaccine. For the three states (South Carolina, Michigan, and Wyoming) where this does not result in strata that have at least nine counties, we dissolve instead by baseline GOP vote share. In total, this left US with 47 strata. However, county-level GOP votes were not available for Alaska, and so this stratification variable was used for the other 18 states in the sample only.

Out of the 1,397 counties which fit the eligibility criteria for the experiment, we assigned 468 counties to the control group, 310 counties to T1 ("Direct" messaging) treatment, 309 counties to T2 ("Friends" messaging), and 310 counties to T3 ("Gossips" messaging).

However, after examining the reported vaccination counts in January 2022, we found that the vaccination counts in Georgia were not reliable, as vaccination rates as large as 25-30% of the counties' populations were reported in a single week, and so Georgia is excluded from the results

[3] https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/

presented below. This results in 1,213 total counties in the experiment, of which 407 are in the control group, 269 in the Direct group, 268 in the Friends group, and 269 in the Gossips group.

France

The experimental sample includes areas where vaccination rates remained low in fall 2021. The unit of randomization is postal codes in Lyon/Paris/Marseille, and “Etablissement public de cooperation intercommunale” (EPCI - a federation of municipalities) in the rest of mainland France (Figure 1.b). The inclusion criteria for the study was areas where below 80% of people were without the first dose of vaccine as of November 2021, and where the data were available on first vaccination doses. Under this criteria, the experimental sample includes 1,030 EPCI and 251 postal codes in France.

Randomization was stratified by three characteristics: 1) region or city, 2) above/below median baseline 1st dose, and 3) above/below median population. For baseline vaccination rates, areas were divided into above- and below-median percentage of the population that had received the first dose of COVID-19 vaccine. In total, this left US with 44 strata for the EPCI and 12 strata for the postal codes in Lyon/Marseille/Paris. Out of the 1,030 EPCI which fit the eligibility criteria for the experiment, we assigned 344 EPCIs to the control group, 343 EPCIs to T1 ("Direct" messaging treatment), and 343 EPCIs to T2 ("Friends" messaging treatment). Out of the 251 postal codes in Lyon/Marseille/Paris which fit the eligibility criteria for the experiment, we assigned 83 postal codes to the control group and 84 postal codes each to the Direct and Friends groups.

2.3 Implementation

United States

The Facebook campaign was implemented by Code3 Creative, which began to implement the campaigns on December 22, 2021, and ran them for five weeks (until January 27, 2022). In total, the Facebook campaigns reached 17,828,769 distinct Facebook users (5,933,089 in the Direct group, 5,952,765 in the Friends group, and 5,942,915 in the Gossips group).

Facebook users did watch the videos served to them about vaccination. The Direct campaign videos received 3,000,319 3-second plays on Facebook, as compared to a slightly lower number in the Friends (2,709,409) and Gossips (2,737,252) campaigns. The Direct campaign videos were watched at least 50% of the way through 309,863 times, as compared to a slightly higher number in the Friends campaign (321,369 views at 50% or more) and fewer in the Gossips campaign (179,315 views at 50% or more).

The fraction of 3-second and 50% play (45-50% and 3-5% respectively) indicate a large engagement with the material compared to industry standards for video ad campaigns. The average Facebook video in December and January 2021 received 3-second views from 40-45% of users[4]. These watch rates are also higher than those in the Facebook campaigns which successfully discouraged people from traveling during Thanksgiving and Christmas, in which the 3-second watch rates were 12-13% and the 15-second watch rates were 1-2% (Breza et al 2021).

However, the click-through rates were low. Only 0.6% of the people who were served the ads clicked on them to visit the website (110,704 in total). Moreover, there is no indication that people were prompted by the social network (immunization ambassador) videos in T2 and T3 to find ways to convince their friends. If anything, the Direct group had the most people who clicked on the ads (40,992), followed by the Friends campaign (35,984) and the Gossips campaign (33,728). Moreover, very few people who visited the website engaged with the content on the website. Approximately 300 unique users watched 2,755 videos, and very few users shared the videos using the tools provided on the website (297 shares in total). Only 5 website visitors signed up to be a "vaccine ambassador." Thus, *prima facie*, there is little evidence that the strategy was successful in motivating people to share resources. If the friends and gossip videos convinced them to talk to their friends, they did so outside the website.

France

Code3 Creative began to roll out the campaign on February 3rd, 2022. We originally planned to run the Facebook campaigns for 4 weeks (until March 3, 2022). However, there was an unexpected pause in the campaigns due to a payment problem with the Facebook ad credits, which resulted in an extension of the ad campaign. Ads were offline from 18 Feb to 28 Feb, and again from March 9 through March 13. Other than these gaps, the ads ran until March 17, 2022. In total, the Facebook campaigns reached 11,518,110 distinct Facebook users (6,378,029 in the Direct group and 5,140,081 in the Friends group).

The Direct campaign videos received 3,339,455 3-second plays on Facebook, as compared to a lower number in the Friends (2,690,155) campaign. The Direct campaign videos were watched at least 50% of the way through 643,998 times, and the Friends campaign videos 476,653 times. As in the US campaign, this number of views (52% for 3-second plays and 9-10% for 50% plays) constitutes a fairly large level of engagement compared to industry standards.

Just as in the US, a small fraction -- although larger than in the US (1.4%) -- of the people who were served the ads clicked on them to visit the website (162,240 in total). The Direct group had more people who clicked on the ads (96,832) than the Friends campaign (65,408). And once

[4] According to the monthly Facebook benchmarks published by Social Status IO: https://www.socialstatus.io/insights/social-media-benchmarks/facebook-video-view-rate-benchmark/

again, not many people who visited the website watched videos on the website, and nearly no one engaged with the sharing tools. 1,627 unique website visitors in France watched videos on the website (3,900 views total). Users in France were more likely to watch videos, but less likely to share them. There were only 50 total shares of the videos, and two people signed up to be vaccine ambassadors. Thus, the general low level of interest in becoming an ambassador was common to both countries.

3. Analysis

To estimate the week-by-week effects of the US Facebook campaigns on the number of vaccinations reported in each county, we estimate the following regression (see Figures 2a-2c):

$$(1) \quad asinh(y_{it}) = \Sigma_t \beta_{1t} Direct_i \times Week_t + \Sigma_t \beta_{2t} Friends_i \times Week_t + \Sigma_t \beta_{3t} Gossips_i \times Week_t + Controls_i + Week_t + State_i + Strata_i + \varepsilon_{it}$$

where y_{it} is the number of new COVID-19 vaccinations in county i during week t and $Controls_i$ are county-level control variables that were LASSO-selected among a pool of demographic characteristics[5]. The selected controls include population, urban/rural status, GOP win margin in the 2016 presidential election and baseline first and second dose vaccination rates. Depending on the specification, y_{it} is either the first dose of vaccine, second dose of vaccine, booster shot, or a sum of all three.

We use the hyperbolic sine transformation because the outcome distribution in the US is approximately log-normal, and some counties had zero new vaccinations. In robustness checks, we also use $log(y_{it} + 1)$ as our outcome variable. Both transformations result in similar estimates.

In some specifications, presented in the appendix (Supplementary Figures 3a-c & Supplementary Table 1), we also exclude GOP vote share in the regression in order to include Alaska in the analysis (Alaska did not make this information public at the county level.)

To analyze the France campaign, we run a similar regression (see Figures 3a-3b):

$$(2) \quad asinh(y_{it}) = \Sigma_t \beta_{1t} Direct_i \times Week_t + \Sigma_t \beta_{2t} Friends_i \times Week_t +$$

[5] We use a Double Post LASSO procedure (Belloni, Chernozhukov & Hansen (2014)) to select relevant predictors. The data on demographic characteristics is taken from the American Community Survey 2019 (https://usa.ipums.org/usa/)

$$Controls_i + Week_t + Region_i + Strata_i + \varepsilon_{it}$$

with the difference here that t denotes two-week periods rather than a one-week period as in the US. This two-week aggregation is done to reduce the number of zeros in the outcome distribution: given the granularity and timeline of our intervention, a substantial fraction of units had zero new vaccinations reported in a given week, some of which resulted from the 10-cases reporting threshold the French administrative data imposes. Thus moving from a week-level aggregation to a 2 weeks-level aggregation reduces the share of zeros from 34.3% to 20.6%, and it is further reduced to 15.2% when using a 3 weeks-level aggregation. Because the new vaccination distribution in France is skewed towards 0, we also carry out a negative binomial specification, presented in the appendix, which gives US similar results (Supplementary Figures 7a-b, 8a-b; Supplementary Tables 6a-b). EPCI- and ZIP-code-level controls include population and baseline vaccination rates as well as LASSO-selected controls from a pool of socio-economic measures[6].

In addition to these week-by-week regressions, we also estimate specifications which aggregate weeks which occurred before, during, and after the campaigns. The estimates from these aggregated time period regressions are presented in Table 2a (United States) and 2b (France) where we report the β_1, β_2 and β_3 (US only) coefficients from the following regression:

(3)
$$\begin{aligned} asinh(y_{it}) = {} & \beta_{0,D} Direct_i + \beta_{1,during} Direct_i \times During_t + \beta_{1,post} Direct_i \times Post_t + \\ & \beta_{0,F} Friends_i + \beta_{2,during} Friends_i \times During_t + \beta_{2,post} Friends_i \times Post_t + \\ & \beta_{0,G} Gossips_i + \beta_{3,during} Gossips_i \times During_t + \beta_{3,post} Gossips_i \times Post_t + \\ & Controls_i + State_i + Strata_i + Week_t + \varepsilon_{it} \end{aligned}$$

The analysis was pre-registered in the AEA RCT Registry, with unique identification numbers AEARCTR-0008711 (United States) and AEARCTR-0008902 (France).

4. Results

4a. Baseline Characteristics

Baseline characteristics by treatment group are presented in Table 1a for the United States and Tables 1b-1c for France generally demonstrate the effectiveness of our randomization.

[6] The socio-economic variables were retrieved from French administrative data (INSEE) and can be found at https://www.insee.fr/fr/statistiques/2021266 and https://www.insee.fr/fr/statistiques/5009236?sommaire=5009255&q=epci

Just before the intervention began on December 21st 2021, the average rates of first dose vaccination were approximately 50% across counties in the experiment (and 45% for complete vaccination rates). The counties in the experiment were mostly non-metro areas; approximately 1 in 3 counties in the experiment was classified as urban. Overall, the counties in the experiment voted for Donald Trump by a wide margin in 2016. The percentage of voters favoring Trump was approximately 68% in the study counties. On average, the counties in the Gossips groups have a larger population (74,617 people on average), as compared to between 55,000-60,000 people on average in Control, Direct, and Friends group counties.

In France, the average rates of first dose vaccination were much higher before the experiment began. Just before the campaigns, the average first dose vaccination rate at the end of January 2022 was approximately 76% across EPCIs (75% for completed vaccination or equivalently, reported recovery from COVID-19)[7]. In the postal code sample, vaccination rates were slightly lower, with an average first dose vaccination rate of 71% (70% for completed vaccination or first dose with reported recovery). EPCI units had populations ranging from 43,797 people on average (Control group) to 55,264 people on average (Direct group), with the Friends group in between (48,378). The difference between Control and Direct group average populations is significant at the 10% level. Postal code units in the control and treatment groups have populations between 25,000 - 30,000 people and are not significantly different between groups.

4b. Effects of the Interventions - United States

Figures 2a-2c present the main results for the US in graphical form. These figures plot the coefficients $\beta_{1,t}$ (Figure 2a), $\beta_{2,t}$ (Figure 2b), and $\beta_{3,t}$ (Figure 2c) obtained when estimating Equation (1) using the number of first dose vaccinations in a week as the outcome variable. Each dot is a coefficient for a particular week, and the whiskers represent 95% confidence intervals. The red dotted vertical lines indicate the beginning and the end of the campaign. We see that none of the coefficients are statistically significant, in none of the Direct (2a), Friends (2b) or Gossips (2c) campaign, and that the coefficients are all very small. In Supplementary Figure 1b we alleviate the concern that the null result for the Direct campaign (Figure 2a) simply results from a systematic pre-trend imbalance by using entropy weighting (Hainmuller 2012) to match pre-intervention periods across groups.

Table 2a shows the overall impact of all three campaigns during and after the intervention period. We find that during the campaign, the estimated coefficient of the Direct campaign is -0.023 (SE 0.040 95% CI -0.10 +0.055). The point estimate after the campaign is -0.017 (SE 0.037, 95% CI -0.090 +0.056). Thus, the point estimates are small and negative, and we can reject an increase in the number of immunizations given of 5.5% during and 5.6% after. Since these are in percent

[7] At the time, the French administration considered people with a first dose of vaccine who were recently infected by COVID-19 to be “fully vaccinated”.

terms, this means we can rule out even quantitatively small impacts: If the campaign had increased the number of vaccinations given during the intervention period by 5.5% in every county, then the *change* in county-level vaccination rates would have increased by 0.13 pp on average (on a basis of + 2.34 pp, which was the increase in vaccination rates for the control group over the treatment period). In other words, a treatment effect of 5.5% would have resulted in a total vaccination rate of 53.64% on average at the end of the intervention, as compared to 53.51% without treatment.

The coefficients for the Friends campaign are -0.007 during the campaign (SE 0.038, 95% CI -0.081 +0.067) and 0.028 (SE 0.045, 95% CI -0.06 +0.12) after the campaign. As in the Direct campaign, the point estimates are very small. We can reject an increase in the number of immunizations given by 6.7% during the campaign and 12% after the campaign. Assuming a 6.7% increase in every treatment county during the campaign, this bounds the positive impact at an average increase of 0.16pp which would have resulted in an average vaccination rate of 53.67% instead of 53.51% in the absence of treatment, again a very small effect.

Lastly, the coefficients for the Gossips campaign are -0.037 during the campaign (SE 0.036, 95% CI -0.11 +0.034) and -0.012 after the campaign (SE 0.044, 95% CI -0.098 +0.074). Again, the point estimates are small and negative, and we can reject a small positive effect on the number of immunizations (3.4% during the campaign and 7.4% after the campaign). If we assume a 3.4% increase in every treatment county during the campaign, then that would have increased vaccination rates by only 0.079pp, resulting in a vaccination rate of 53.59% at the end of the intervention compared to 53.51% in the absence of treatment.

Our ability to rule out effects smaller than 1pp despite the large engagement on Facebook relative to industry standards for sponsored content provides strong evidence in favor of a null effect. It is not that people did not watch the vaccination-related content. Rather, they chose not to follow up on the content by getting vaccinated or signing up to be a vaccine ambassador. Further suggestive evidence in favor of the null is provided by the randomization inference p-values reported in Table 2a, which alleviate the concern that results might be an artifact of our specific randomization. In the appendix, we show a similar lack of an effect on our other measures of vaccinations in the US (any vaccine, second vaccines, and booster shots - Supplementary Figure 1a, Supplementary Tables 2 & 3). We also present results of regressions which pool together the Friends and Gossips campaigns and still do not find any treatment effect (Supplementary Figure 4).

In the US, we had pre-registered looking at heterogeneity by political leanings, urban/rural, and prior immunization status. These results are presented in the appendix (Supplementary Tables 4 and 5). We do not find any differences by these characteristics, although it is worth noting that nearly all of our sample was Republican-leaning, rural, and low immunization, so given how it was selected, these are gradations within this group.

4c. Effects of the Interventions - France

Figures 3a and 3b show the week-by-week results for France. Here again, we see no impact either of the Direct campaign (Figure 3a) or the Friends campaign (Figure 3b). In Supplementary Figures 2a-b we show that these results are robust to using a 3-week aggregation.

Table 2b shows the overall impacts of the campaign for France, aggregating weeks into the time periods of before, during, and after the campaign. We find that during the campaign, the estimated coefficient of the Direct campaign is 0.013 (SE 0.032 95% CI -0.050 +0.076). The point estimate after the campaign is -0.038 (SE 0.048, 95% CI -0.132 +0.056). The point estimates of the effects of the campaign are very small, and we can reject an increase in the number of immunizations given of 7.6% during and 5.6% after. If the campaign had increased the number of vaccinations given during the intervention period by 7.6% in every area then that would have increased the *change* in EPCI and postal code vaccination rates during the treatment period by 0.021pp on average (on a base of 0.27pp increase for the control group over the treatment period). In other words, a positive effect of 7.6% in each area would have resulted in an EPCI and postal code vaccination rates of 75.62% on average at the end of the intervention, as compared to the control group mean of 75.60% at the end of the intervention period.

The coefficients for the friends campaign are 0.005 during the campaign (SE 0.033, 95% CI -0.060 +0.070) and 0.047 (SE 0.048, 95% CI -0.047 +0.14) after the campaign. As in the Direct campaign, the point estimates are small and insignificant. We can reject an increase in the number of immunizations given by 7.0% during the campaign and 14% after the campaign. Using similar logic, this bounds the positive impact at an average increase of the *change* in EPCI and postal code vaccination rates during the treatment period by 0.019 pp on a base of 0.27 pp. This change would have resulted in a vaccination rate of 75.62% at the end of the intervention, again compared to 75.60% in the absence of treatment.

5. Discussion

Neither a direct campaign outreach campaign by doctors, nor the two campaigns that attempted to activate local social networks by enrolling ambassadors, were effective in increasing COVID-19 vaccination during the winter of 2021-2022, approximately one year after vaccines first became available, and in the middle of the Omicron wave, when vaccination was key to preventing morbidity and mortality.

This contrasts with the effectiveness of these methods in closely related contexts. Earlier in the COVID-19 pandemic, doctors and laypeople outreach was effective in encouraging the take up of other preventive behaviors and vaccines other than the COVID-19 vaccine (Alsan & Eichmeyer 2021, Breza et al. 2021, Banerjee et al. 2019). However, these campaigns -- unlike the one in this study -- focused on non-pharmacological interventions.

In the US, one possible explanation is that, by the winter of 2021-2022, opinions about the vaccines (whether for or against) were already firmly held by most people, and there remained few people who could be nudged. In January 2022, Kaiser Family Foundation polling found that the share of those saying that they would definitely not get vaccinated was 14%, a share that had held constant since December 2020. At that time, only 4% of people wanted to "wait and see" before getting the vaccine, 3% said they would get vaccinated if they were required (by school or work), and 1% that they would do it as soon as possible. The rate of those declaring that they had received one dose was 77% (up from 73% in November 2021) (Hamel et al. 2022, KFF). Thus, despite the new studies on the effectiveness of vaccination and boosters during the Omicron wave, the vaccine "hesitancy" had all but vanished: there were only the vaccinated and the vaccine resistant. This is an environment where nudges were less likely to be useful.

This is particularly plausible given the high levels of engagement with the Facebook content (about 45-50% of ad recipients saw the first 3 seconds of the videos in the US and 52% in France in both treatment arms): participants chose not to follow-up. This lack of interest in following up may be because the people who remained unvaccinated at the time of the intervention were the "last mile" people who were least easily persuaded to get a COVID-19 vaccine. It likely did not help that over the course of 2020 and 2021, people's opinions may have become more firmly entrenched as COVID-19 vaccines became more politicized. Lastly, people's calculations of marginal benefits to marginal costs may have shifted as Omicron became the prevalent variant over the course of the study; Omicron appears to be less likely to result in hospitalization than the Delta variant, and also seems to be able to evade vaccines more easily for infection (Sheikh et al. 2022).

In France, an additional factor is that strong incentives to get vaccinated were introduced during the summer of 2021, with a health pass (vaccine or tests), and then a vaccine pass, required for many activities, from restaurant dining to transportation. When boosters were made available to all, a booster or a prior infection was obligatory for a full health pass. The avowed strategy of the President was to make life extremely difficult for unvaccinated people. Thus, people who remained unvaccinated were also probably extremely determined in their opposition to the vaccine, and anyone who was willing to get vaccinated had many reasons to not procrastinate.

Nevertheless, these results suggest that if vaccination rates are going to continue to progress in both countries and in other places where it remains low, different strategies need to be mobilized.

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FIGURES AND TABLES

Figure 1a: United States Randomization

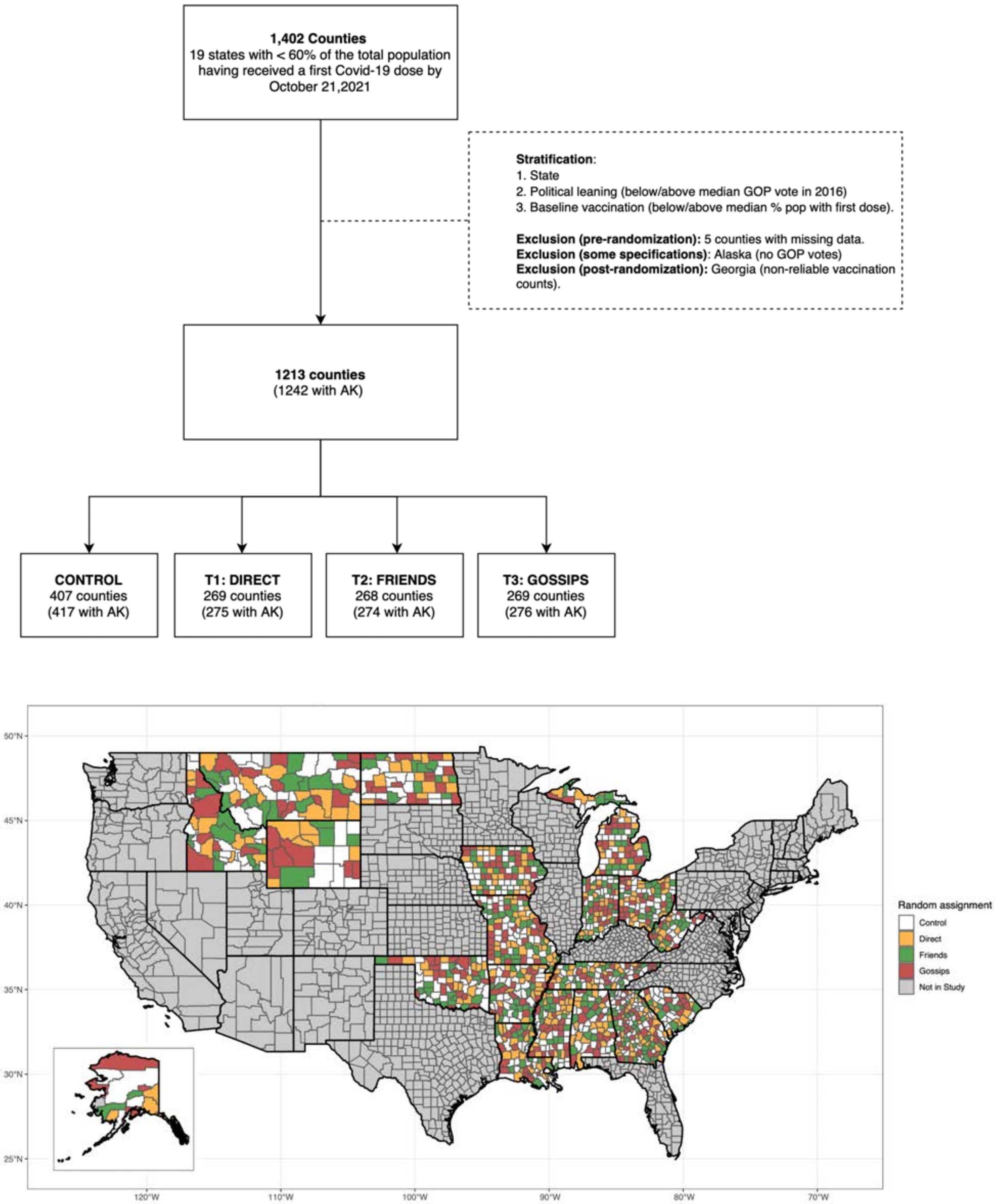
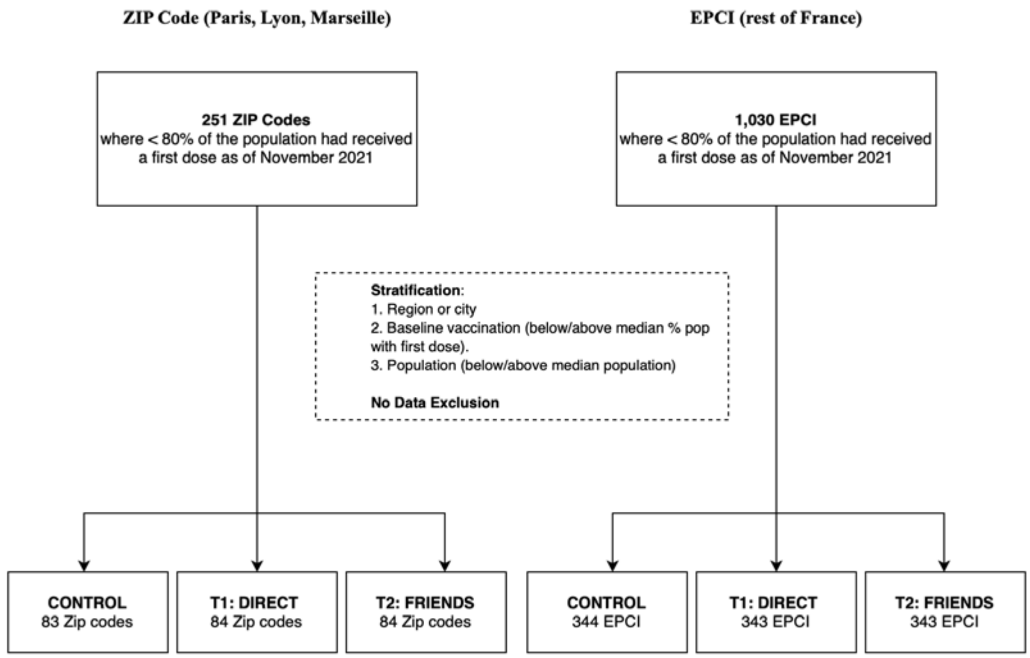


Figure 1b: France Randomization



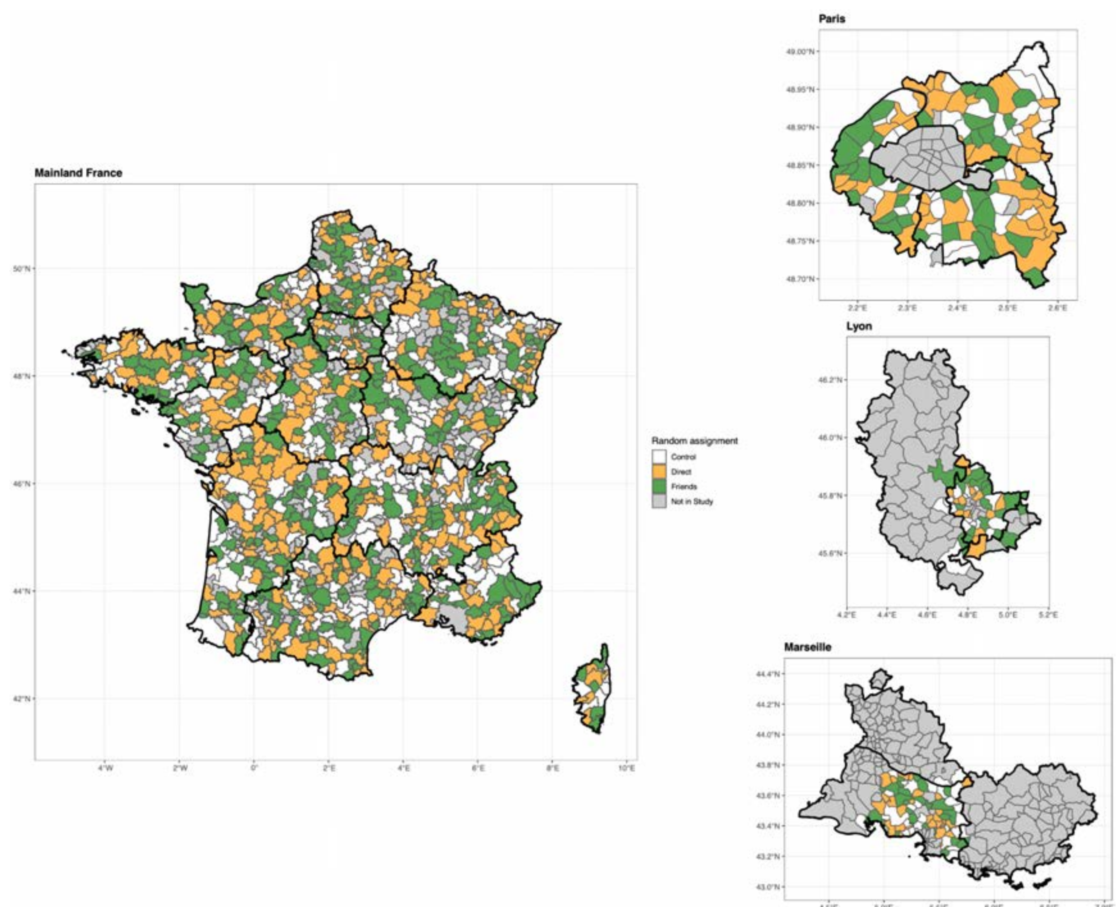
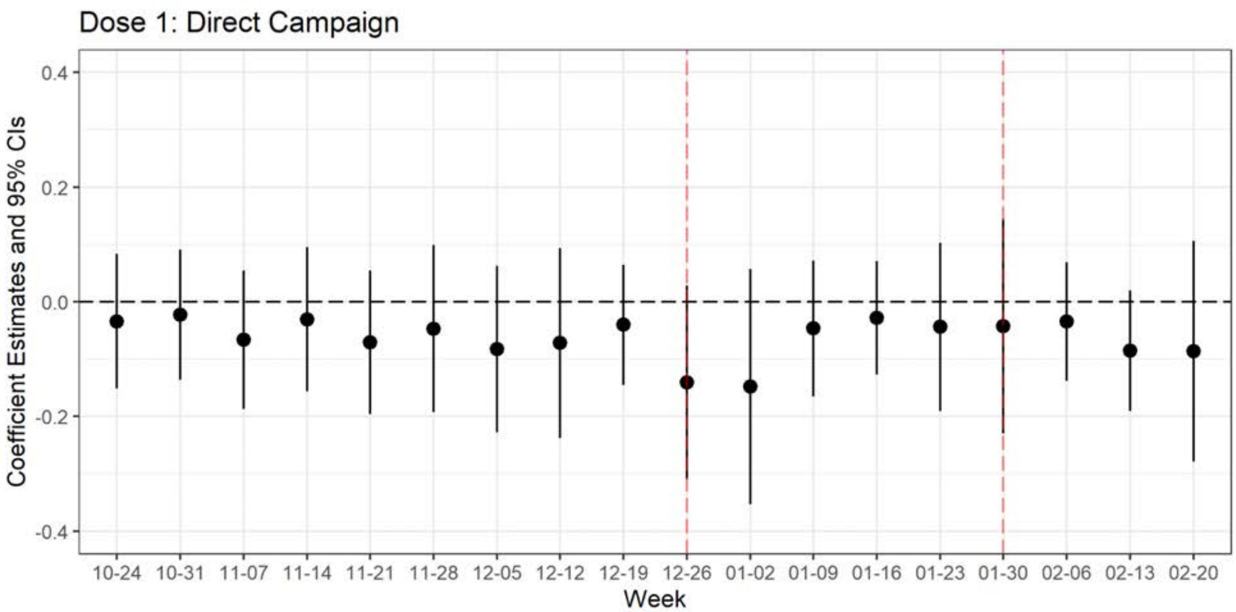
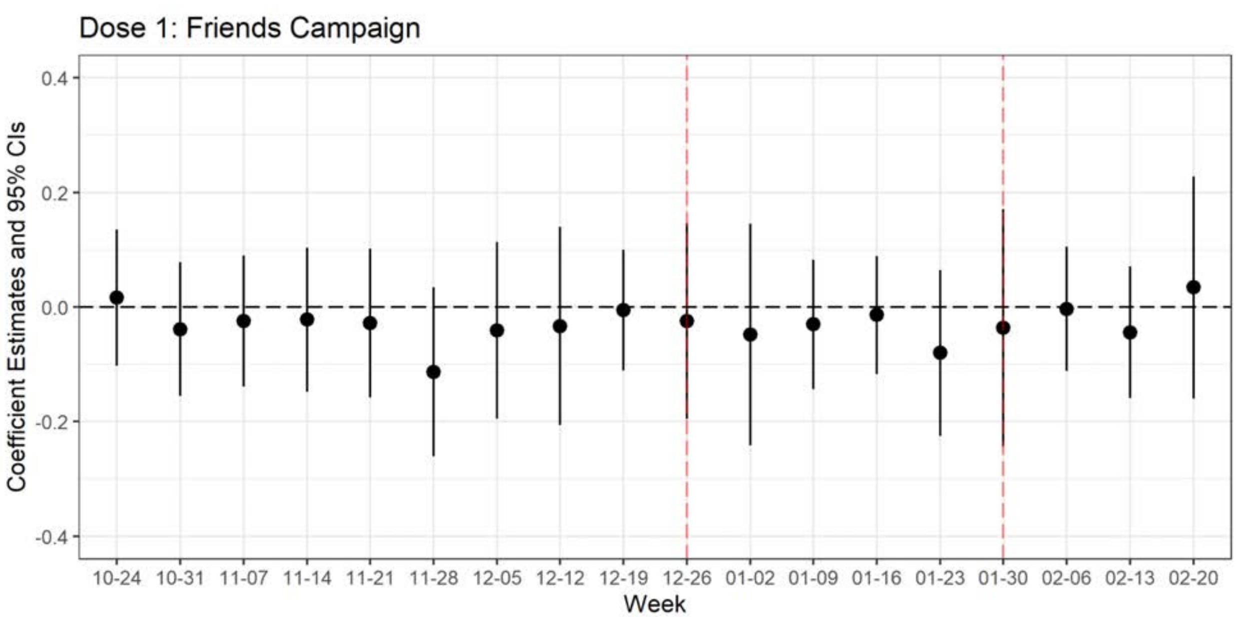


Figure 2a: Week-by-week impact of the <u>Direct</u> campaign on 1st dose vaccination, USA



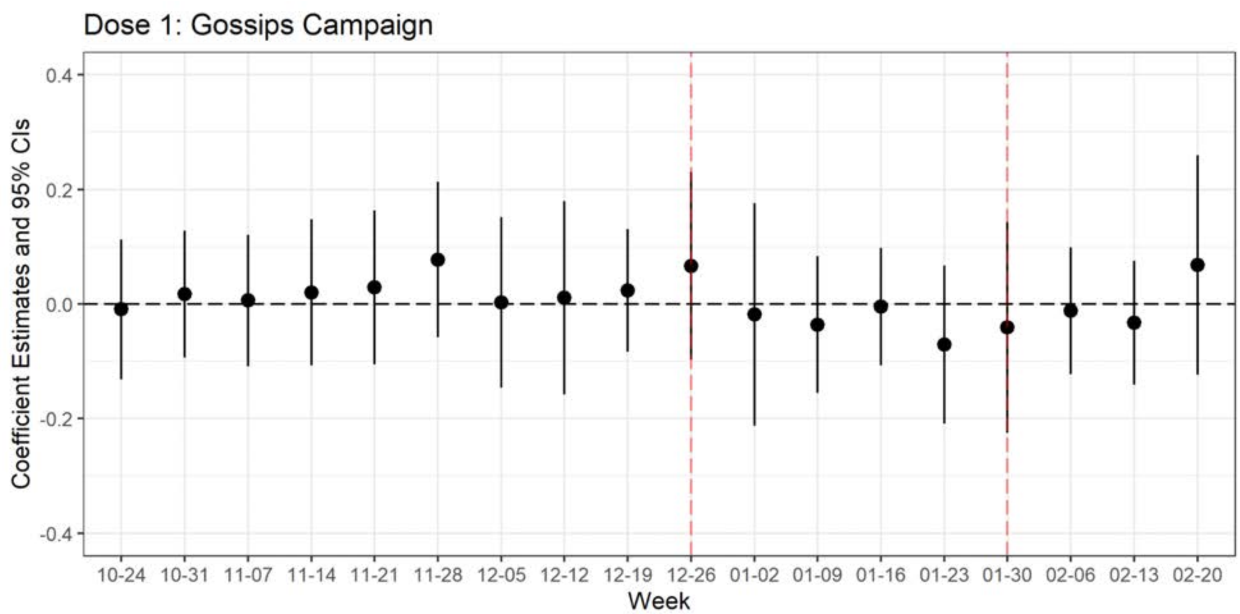
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (1) for the US with 95% confidence intervals, using the number of first dose vaccinations in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Figure 2b: Week-by-week impact of the <u>Friends</u> campaign on 1st dose vaccination, USA



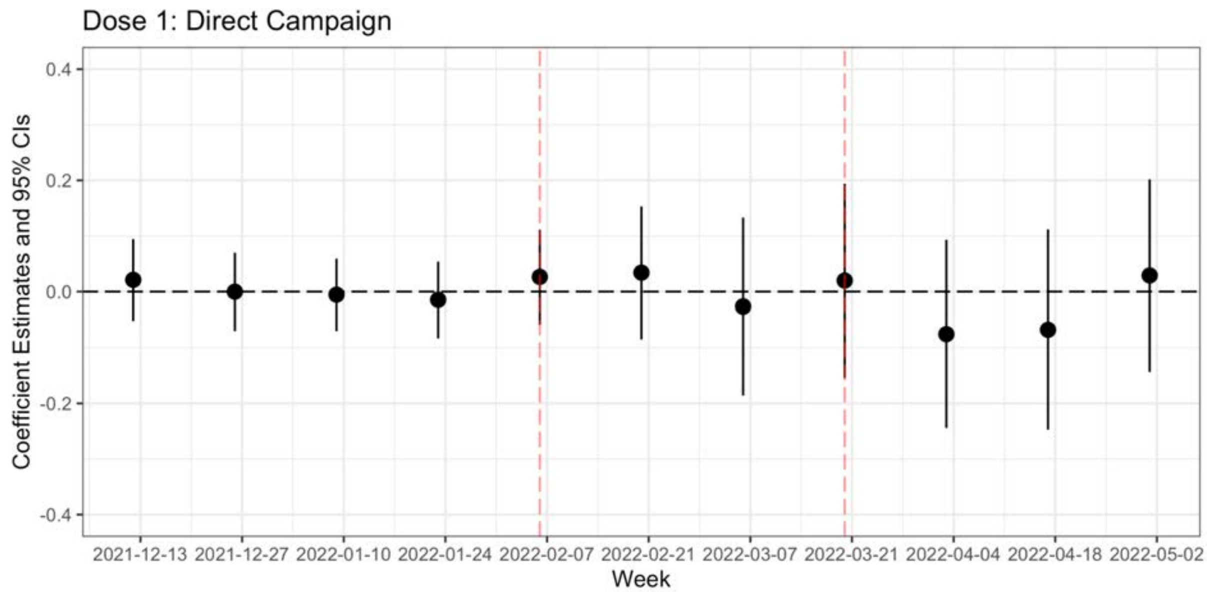
Notes: This figure presents the estimated coefficients $\beta_{2,t}$ in Equation (1) for the US with 95% confidence intervals, using the number of first dose vaccinations in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Figure 2c: Week-by-week impact of the <u>Gossips</u> campaign on 1st dose vaccination, USA



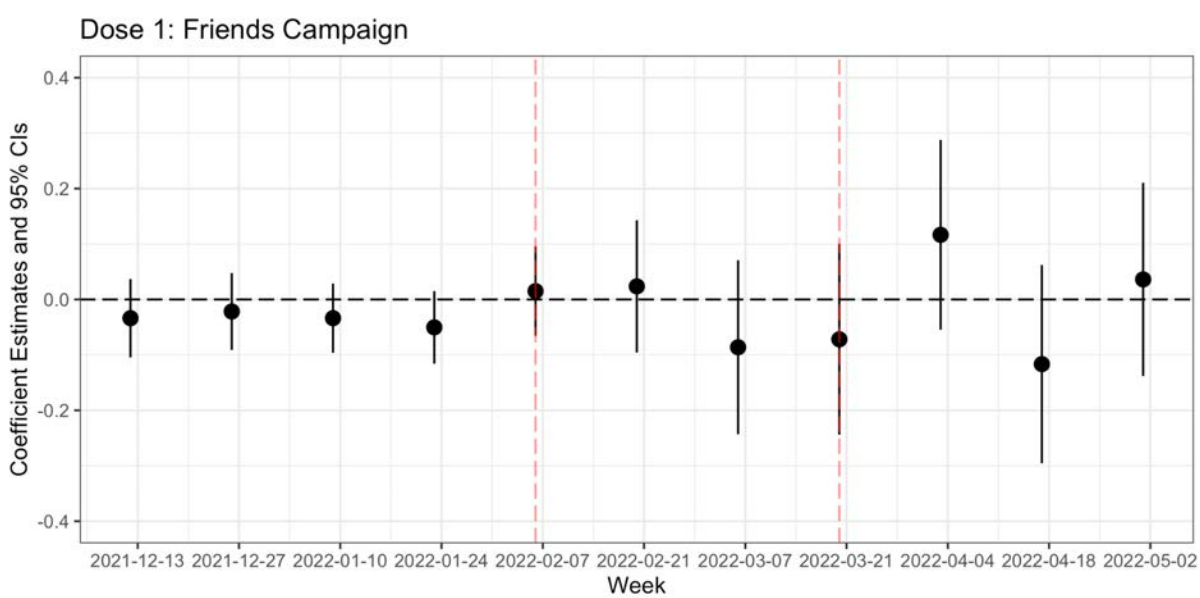
Notes: This figure presents the estimated coefficients $\beta_{3,t}$ in Equation (1) for the US with 95% confidence intervals, using the number of first dose vaccinations in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Figure 3a: Two-week-by-two-week impact of the Direct campaign on first vaccination, France



Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (2) for France along with 95% confidence intervals, using the number of first dose vaccinations within two weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Figure 3b: Two-week-by-two-week impact of the Friends campaign on first vaccination, France



Notes: This figure presents the estimated coefficients $\beta_{2,t}$ in Equation (2) for France along with 95% confidence intervals, using the number of first dose vaccinations within two weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Table 1a: Baseline Characteristics by Treatment Group (United States, Counties)

		(1) Control		(2) Direct		(3) Friends		(4) Gossips	T-test P-value					
Variable	N	Mean/SE	N	Mean/SE	N	Mean/SE	N	Mean/SE	(1)-(2)	(1)-(3)	(1)-(4)	(2)-(3)	(2)-(4)	(3)-(4)
GOP Win Margin (2016)	407	0.388 (0.014)	269	0.372 (0.018)	268	0.384 (0.016)	269	0.375 (0.016)	0.471	0.869	0.555	0.607	0.882	0.695
GOP Vote 2016 (%)	407	0.685 (0.007)	269	0.677 (0.009)	268	0.683 (0.008)	269	0.678 (0.008)	0.476	0.866	0.532	0.615	0.911	0.674
Urban Counties (%)	417	0.312 (0.023)	275	0.302 (0.028)	274	0.299 (0.028)	276	0.377 (0.029)	0.782	0.728	0.076	0.948	0.063	0.055
Baseline Complete Vacc (%)	417	45.797 (0.503)	275	45.404 (0.612)	274	44.800 (0.608)	276	45.479 (0.588)	0.621	0.209	0.684	0.485	0.929	0.423
Baseline Dose 1 Vacc (%)	417	52.100 (0.567)	275	51.757 (0.712)	274	50.870 (0.684)	276	51.699 (0.636)	0.706	0.169	0.645	0.369	0.951	0.375
Population	417	55104.763 (5109.717)	275	59720.731 (7280.587)	274	58041.000 (8236.215)	276	74617.257 (9521.786)	0.593	0.749	0.051	0.879	0.215	0.189

Note: In this table, columns (1), (2) and (3) show the means and standard errors of the main county-level characteristics of the treatment groups for the US. Columns (5) to (10) present the p-value under the null hypothesis that column (i) and (j) do not have the same mean.

Table 1b: Baseline Characteristics by Treatment Group (France, Postal Codes)

		(1) Control		(2) Direct		(3) Friends	T-test P-value		
Variable	N	Mean/SE	N	Mean/SE	N	Mean/SE	(1)-(2)	(1)-(3)	(2)-(3)
Population: 00-19	83	6449.759 (629.485)	84	6079.167 (678.098)	84	7044.286 (755.233)	0.689	0.547	0.343
Population: 20-64	83	15942.892 (1517.716)	84	14978.095 (1685.071)	84	17617.024 (2007.027)	0.671	0.507	0.315
Population: 65+	83	4416.386 (389.870)	84	4099.167 (389.593)	84	4774.405 (541.271)	0.566	0.593	0.313
Population: All Ages	83	26806.747 (2498.868)	84	25152.024 (2729.761)	84	29432.619 (3268.272)	0.656	0.525	0.316
Baseline Dose 1 (%)	83	0.706 (0.007)	84	0.710 (0.006)	84	0.709 (0.006)	0.678	0.756	0.919
Baseline Complete Vacc (%)	83	0.694 (0.007)	84	0.698 (0.006)	84	0.697 (0.007)	0.714	0.750	0.965

Note: In this table, columns (1), (2) and (3) show the means and standard errors of the main postal-code-level characteristics of the treatment groups for France. Columns (5) to (10) present the p-value under the null hypothesis that column (i) and (j) do not have the same mean.

Table 1c: Baseline Characteristics by Treatment Group (France, EPCI)

Variable	(1) Control N	(1) Control Mean/SE	(2) Direct N	(2) Direct Mean/SE	(3) Friends N	(3) Friends Mean/SE	T-test P-value (1)-(2)	T-test P-value (1)-(3)	T-test P-value (2)-(3)
Population: 00-19	344	9551.744 (988.230)	343	12055.364 (1070.309)	343	10517.843 (995.168)	0.086	0.491	0.293
Population: 20-64	344	24431.831 (2425.680)	343	31113.615 (2783.969)	343	27149.417 (2670.180)	0.071	0.451	0.304
Population: 65+	344	9814.884 (748.555)	343	12098.426 (905.604)	343	10712.566 (914.482)	0.052	0.448	0.282
Population: All Ages	344	43797.035 (4136.446)	343	55263.965 (4729.148)	343	48378.309 (4546.412)	0.068	0.456	0.294
Baseline Dose 1 (%)	344	0.764 (0.002)	343	0.762 (0.002)	343	0.761 (0.002)	0.297	0.182	0.760
Baseline Complete Vacc (%)	344	0.753 (0.002)	343	0.750 (0.002)	343	0.749 (0.002)	0.296	0.176	0.749

Note: In this table, columns (1), (2) and (3) show the means and standard errors of the main EPCI-level characteristics of the treatment groups for France. Columns (5) to (10) present the p-value under the null hypothesis that column (i) and (j) do not have the same mean.

Table 2a: Effects of Facebook campaigns on new COVID-19 dose 1 vaccinations, United States

	(1)	(2)
	Asinh(New Dose 1)	Log(New Dose 1 + 1)
Direct Campaign		
Direct x during	−0.023	−0.017
	(0.040)	(0.037)
	$p = 0.560$, $RI\ p = 0.726$	$p = 0.641$, $RI\ p = 0.726$
Direct x post	−0.017	−0.008
	(0.043)	(0.038)
	$p = 0.696$, $RI\ p = 0.61$	$p = 0.832$, $RI\ p = 0.61$
Friends Campaign		
Friends x during	−0.007	−0.006
	(0.038)	(0.035)
	$p = 0.863$, $RI\ p = 0.57$	$p = 0.875$, $RI\ p = 0.57$
Friends x post	0.028	0.038
	(0.045)	(0.040)
	$p = 0.533$, $RI\ p = 0.115$	$p = 0.333$, $RI\ p = 0.115$
Gossips Campaign		
Gossips x during	−0.037	−0.034
	(0.036)	(0.034)
	$p = 0.310$, $RI\ p = 0.892$	$p = 0.309$, $RI\ p = 0.892$
Gossips x post	−0.012	−0.011
	(0.044)	(0.039)
	$p = 0.788$, $RI\ p = 0.644$	$p = 0.777$, $RI\ p = 0.644$
Observations	21834	21834
Avg % with Dose 1 at Baseline	51.3	51.3
Week Fixed Effects	Yes	Yes
Strata Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes

* p < 0.1, ** p < 0.05, *** p < 0.01

Note: This table presents the result of estimating Equation (3) for the US. Only the β_1, β_2 and β_3 coefficients are reported and show the effect of the campaigns on the inverse hyperbolic sine (Column 1) or logarithm (Column 2) of new weekly first doses. Standard errors are reported in parentheses and we provide standard p-value and p-values from randomization inference of the estimated coefficients below. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level characteristics. Standard errors have been clustered at the county level.

Table 2b: Effects of Facebook campaigns on new COVID-19 dose 1 vaccinations, France

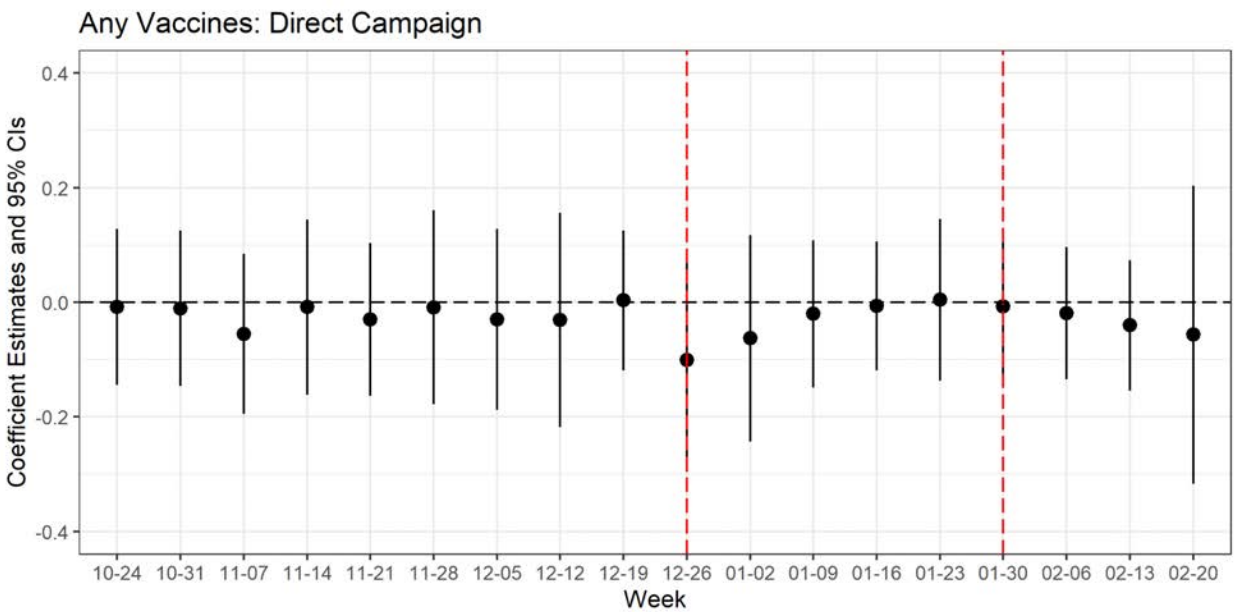
	(1)	(2)
	Asinh(New Dose 1)	Log(New Dose 1 + 1)
Direct Campaign		
Direct x during	0.013	0.011
	(0.032)	(0.025)
	p = 0.676, RI p = 0.289	*p = 0.665, RI p = 0.293*
Direct x post	−0.038	−0.034
	(0.048)	(0.038)
	p = 0.426, RI p = 0.827	*p = 0.383, RI p = 0.843*
Friends Campaign		
Friends x during	0.005	0.006
	(0.033)	(0.026)
	p = 0.879, RI p = 0.424	*p = 0.820, RI p = 0.386*
Friends x post	0.047	0.037
	(0.048)	(0.039)
	p = 0.331, RI p = 0.119	*p = 0.338, RI p = 0.127*
Observations	13981	13981
Avg % with Dose 1 at Baseline	0.75	0.75
Week Fixed Effects	Yes	Yes
Strata Fixed Effects	Yes	Yes
Region Fixed Effects	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of estimating Equation (3) for France. Only the β_1, and β_2 coefficients are reported and show the effect of the campaigns on the inverse hyperbolic sine (Column 1) or logarithm (Column 2) of new first doses within two weeks. Standard errors are reported in parentheses and we provide standard p-values and p-values from randomization inference of the estimated coefficients below. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

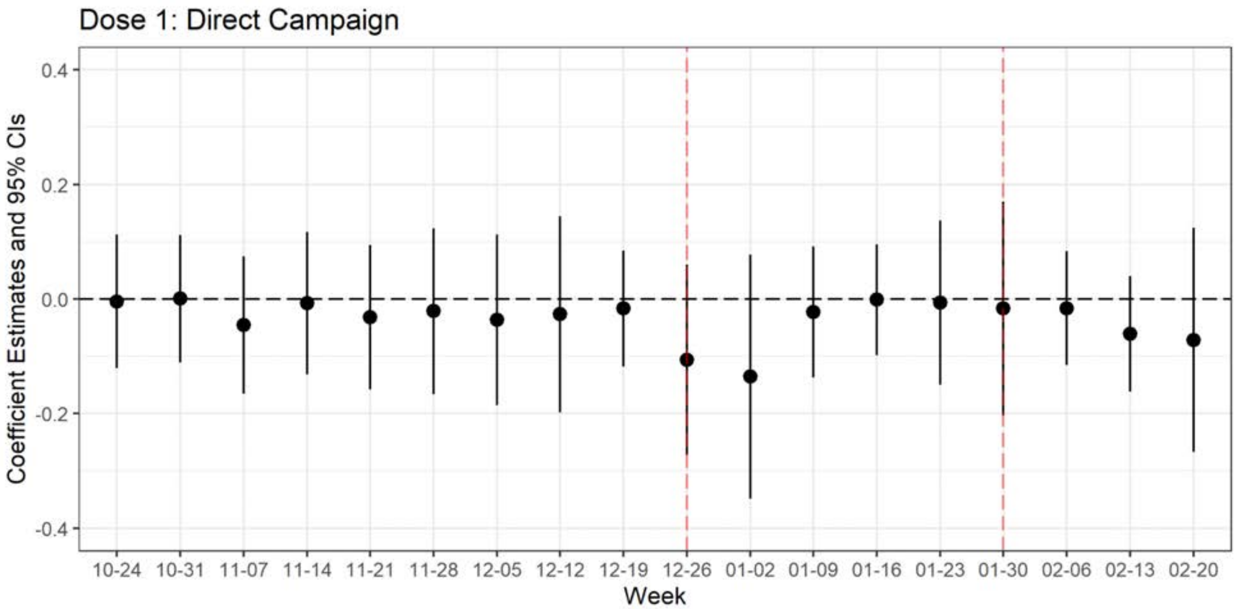
APPENDIX

Supplementary Figure 1a: Week-by-week impact of the Direct campaign on any vaccination, USA



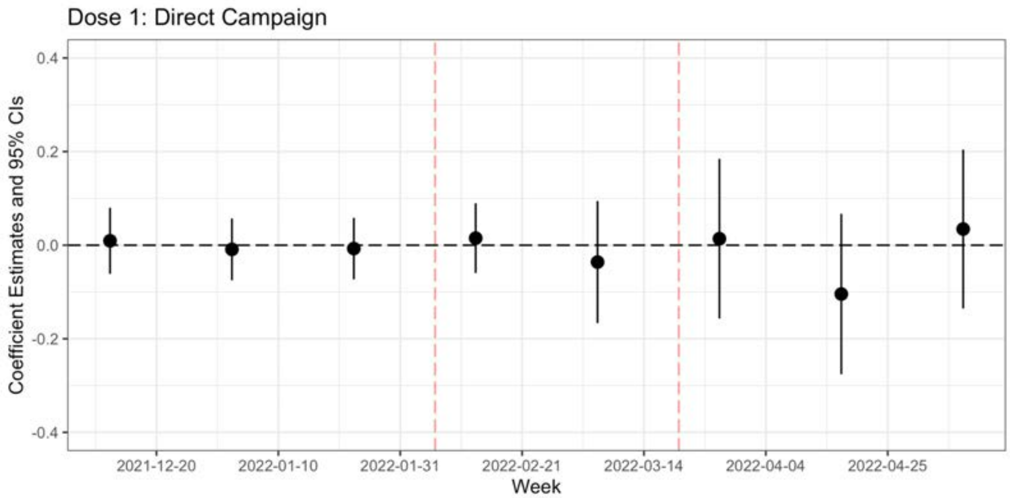
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (1) for the US along with 95% confidence intervals, using the number of any new vaccine dose - either first, second or booster dose - in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level characteristics. Standard errors have been clustered at the county level.

Supplementary Figure 1b: Week-by-week impact of the Direct campaigns on first vaccination with entropy weighting, USA



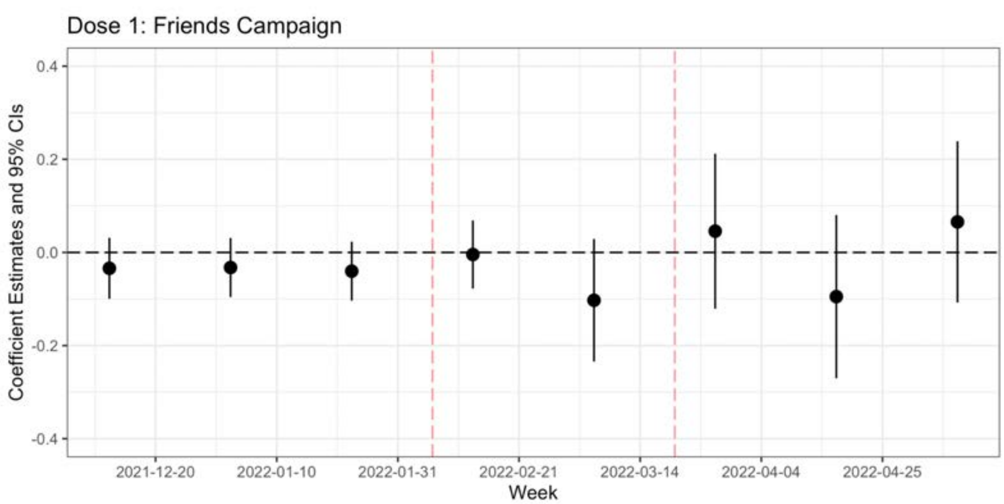
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (1) for the US along with 95% confidence intervals using the number of any new vaccine dose - either first, second or booster dose - in a week as the outcome variable. The regression includes entropy weights calibrated to match the Direct and Control groups on county-level characteristics (population, urban/rural status, political leaning, baseline vaccination rates) and pre-intervention vaccination counts.The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 2a: Three-week-by-three-week impact of the Direct campaign on first vaccination, France



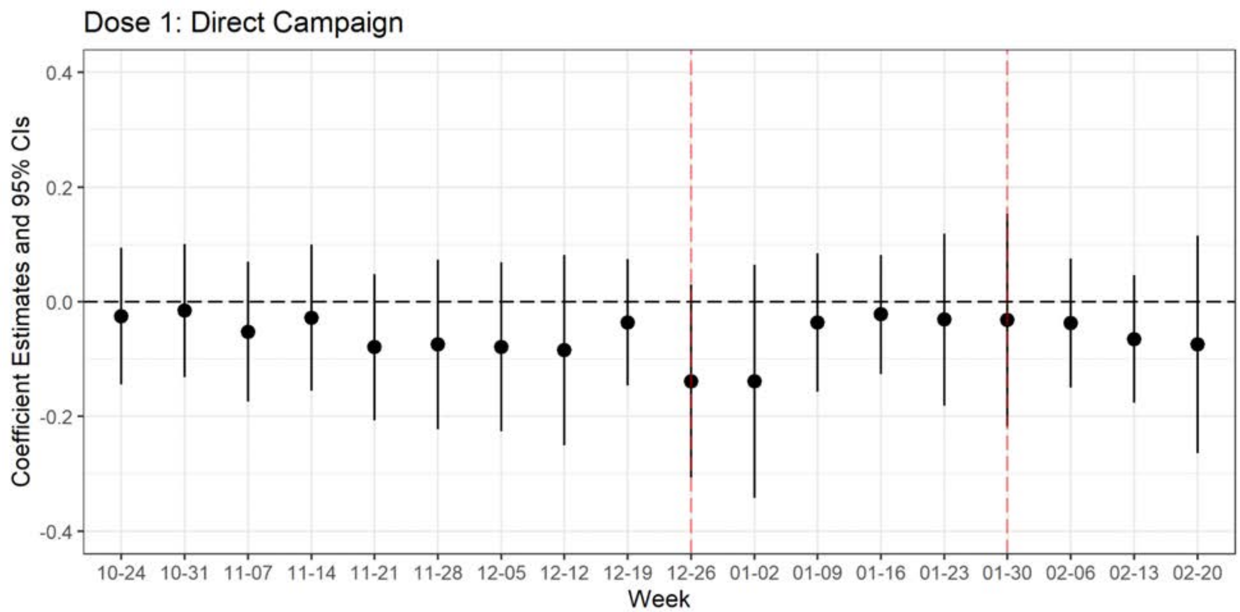
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (2) for France along with 95% confidence intervals, using the number of first dose vaccinations within three weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Figure 2b: Three-week-by-three-week impact of the the Friends campaign on first vaccination, France



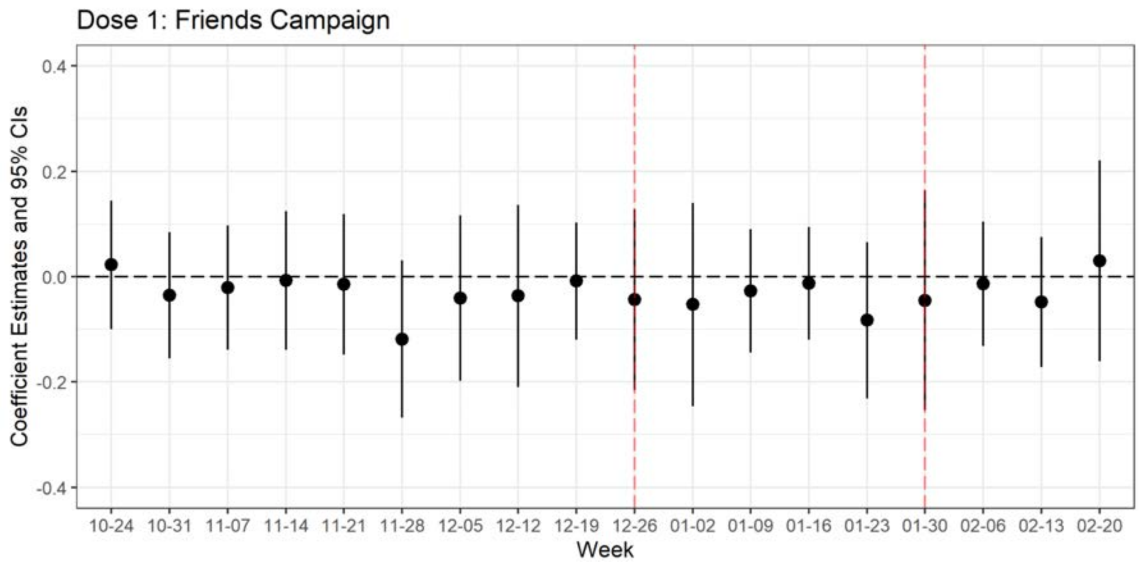
Notes: This figure presents the estimated coefficients $\beta_{2,t}$ in Equation (2) for France along with 95% confidence intervals using the number of first dose vaccinations within three weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Figure 3a: Week-by-week impact of the Direct campaign on 1st dose vaccination, USA (with Alaska)



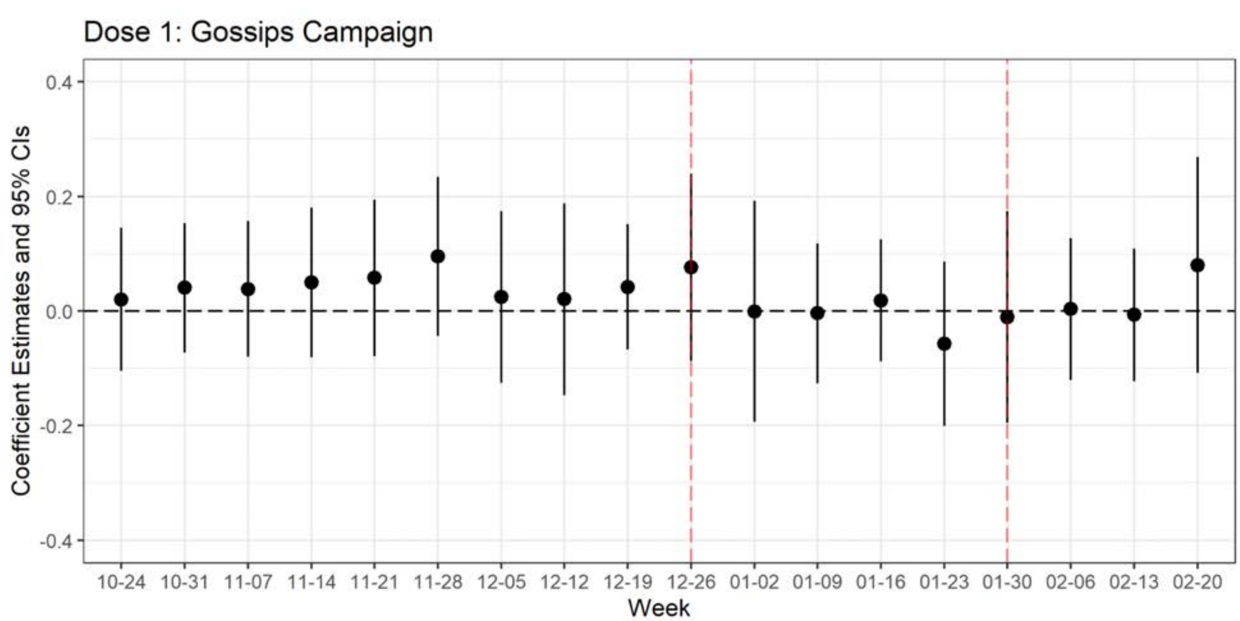
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ in Equation (1) for the US along with 95% confidence intervals including Alaska using the number of any new vaccine dose - either first, second or booster dose - in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 3b: Week-by-week impact of the <u>Friends</u> campaign on 1st dose vaccination, USA (with Alaska)



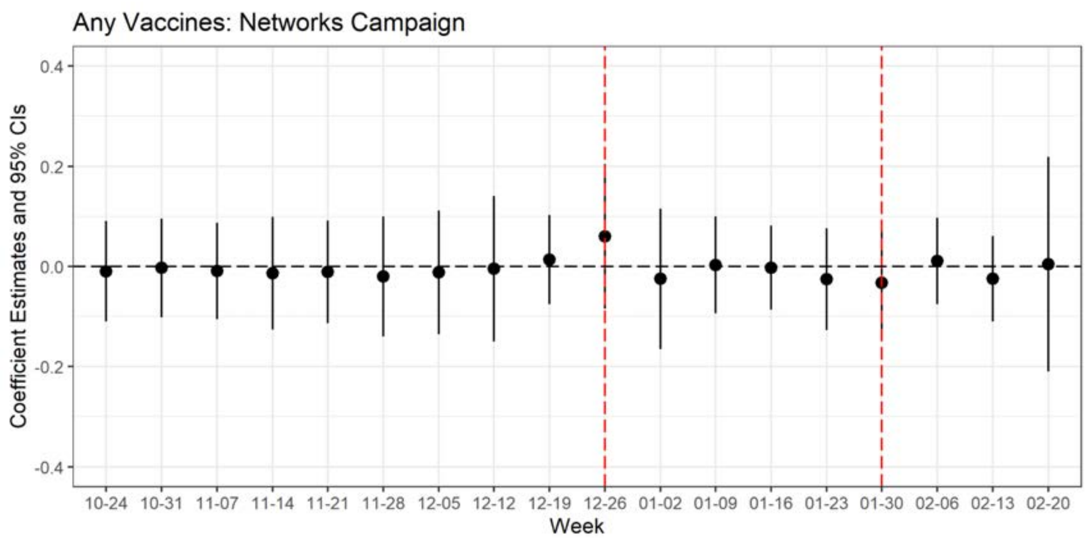
Notes: This figure presents the estimated coefficients $\beta_{2,t}$ in Equation (1) for the US including Alaska along with 95% confidence intervals using the number of any new vaccine dose -either first, second or booster dose - in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 3c: Week-by-week impact of the <u>Gossips</u> campaign on 1st dose vaccination, USA (with Alaska)



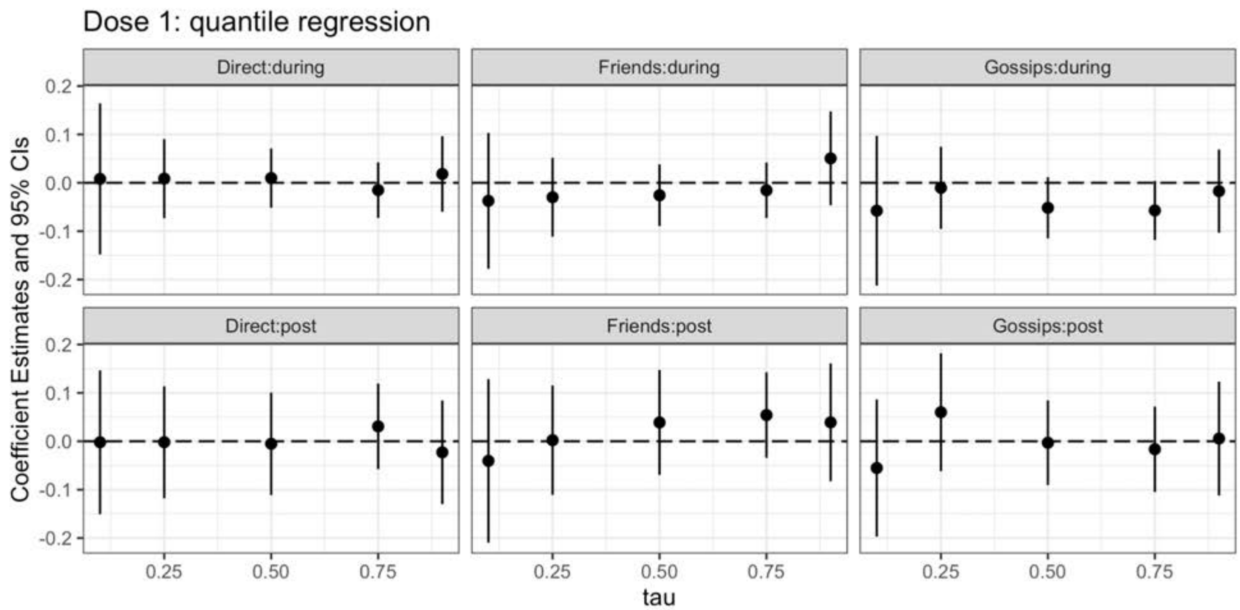
Notes: This figure presents the estimated coefficients $\beta_{3,t}$ in Equation (1) for the US including Alaska along with 95% confidence intervals using the number of any new vaccine dose -either first, second or booster dose - in a week as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 4: Week-by-week impact of the Friends and Gossips campaigns (pooled) on any vaccination, USA



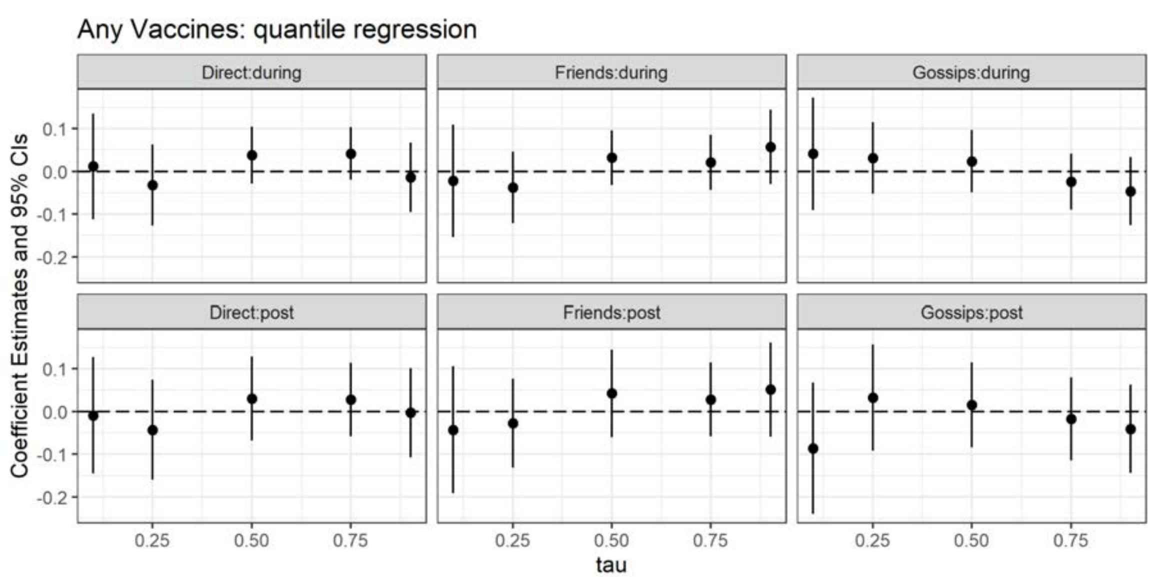
Notes: This Figure presents the estimated Friends + Gossips coefficients of a regression similar to Equation (1) for the US, where Friends and Gossips have been pooled in one treatment group (called "Networks"). The number of any new vaccine dose - either first, second or booster dose - in a week is used as the outcome variable. The 95% confidence intervals are plotted. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls, from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 5a: Quantile regression on 1st dose vaccination, USA



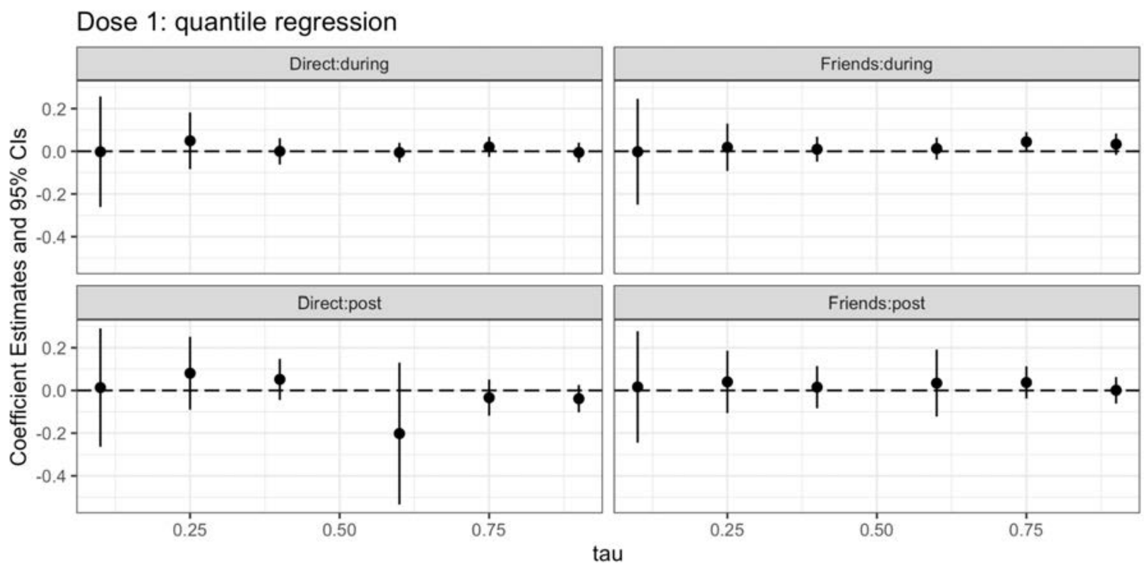
Note: These figures present the results of the quantile regressions based on Equation (1) for the US, using the number of any new vaccine dose - either first, second or booster dose - in a week as the outcome variable. Only $\beta_{1,t}$, $\beta_{2,t}$ and $\beta_{3,t}$ are shown. The 95% confidence intervals are plotted. The standard quantiles are used: 5%, 25%, 50%, 75% and 95%. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls, from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 5b: Quantile regression on any vaccines, USA



Note: These figures present the results of the quantile regressions based on Equation (1) for the US, using the number of any new vaccine dose - either first, second or booster dose - in a week as outcome variable. Only $\beta_{1,t}$, $\beta_{2,t}$ and $\beta_{3,t}$ are shown. The 95% confidence intervals are represented. The standard quantiles are used: 5%, 25%, 50%, 75% and 95%. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls, from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Figure 6: Quantile regression on 1st dose vaccination, France



Note: These figures present the results of the quantile regressions based on Equation (2) for France, using the number of first doses within two weeks as the outcome variable. Only $\beta_{1,t}$ and $\beta_{2,t}$ are shown. The 95% confidence intervals are plotted. For France, we use the following quantiles: 10%, 25%, 40%, 60%, 75% and 95%. We use the 40th and 60th quantile instead of the median because of discontinuities in the outcome variable in the post period around the median, leading to highly imprecise estimates. Regressions include week and region fixed effects, as well as population and baseline vaccination rates controls. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Table 1: Effects of Facebook campaigns on new COVID-19 dose 1 vaccinations, USA (with Alaska)

	Asinh(New Dose 1)	Log(New Dose 1 + 1)
Direct x during	−0.014	−0.009
	(0.039)	(0.036)
Direct x post	−0.006	0.000
	(0.043)	(0.038)
Friends x during	−0.015	−0.014
	(0.039)	(0.036)
Friends x post	0.018	0.028
	(0.046)	(0.041)
Gossips x during	−0.039	−0.037
	(0.036)	(0.033)
Gossips x post	−0.018	−0.018
	(0.044)	(0.039)
% Dose 1 at Baseline	0.101***	0.097***
	(0.014)	(0.013)
Observations	22 356	22 356
Avg % with Dose 1 at Baseline	51.7	51.7
Week Fixed Effects	Yes	Yes
Strata Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes

* p < 0.1, ** p < 0.05, *** p < 0.01

Note: This table presents the result of estimating Equation (3) for the US, including Alaska. Only β_1, β_2 and β_3 are reported and show the effects of the campaigns on the inverse hyperbolic sine (Column 1) or the logarithm (Column 2) of the number of new first doses in a week. Standard errors are reported in parentheses. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls, from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Table 2: Effects of Facebook campaigns on new COVID-19 completed vaccinations, USA

	Asinh(New Completed)	Log(New Completed + 1)
Direct x during	−0.017	−0.012
	(0.037)	(0.034)
Direct x post	−0.028	−0.018
	(0.052)	(0.045)
Friends x during	0.021	0.019
	(0.039)	(0.035)
Friends x post	0.018	0.024
	(0.051)	(0.045)
Gossips x during	0.034	0.033
	(0.039)	(0.035)
Gossips x post	−0.019	−0.012
	(0.053)	(0.047)
% Complete at Baseline	−0.068***	−0.064***
	(0.014)	(0.013)
Observations	21 834	21 834
Avg % with Completed vacc. at Baseline	45.08	45.08
Week Fixed Effects	Yes	Yes
Strata Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of the estimation of Equation (3) for the US. Only β_1, β_2 and β_3 are reported and show the effects of the campaigns on the inverse hyperbolic sine (Column 1) or the logarithm (Column 2) of the number of new completed vaccinations within a week. Standard errors of the estimated coefficients are reported in parentheses. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls, from a pool of county-level characteristics. Standard errors have been clustered at the county level.

Supplementary Table 3: Effects of Facebook campaigns on new COVID-19 booster vaccinations, USA

	Asinh(New Boosters)	Log(New Boosters + 1)
Direct	−0.031	−0.031
	(0.047)	(0.045)
Friends	−0.019	−0.018
	(0.049)	(0.047)
Gossips	−0.002	−0.002
	(0.048)	(0.046)
Direct x post	0.016	0.016
	(0.043)	(0.038)
Friends x post	0.006	0.015
	(0.044)	(0.039)
Gossips x post	0.012	0.011
	(0.044)	(0.040)
Observations	9704	9704
Week Fixed Effects	Yes	Yes
Strata Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of the estimation of Equation (3) for the US. Only the β_1, β_2 and β_3 coefficients are reported and show the effects of the campaigns on the inverse hyperbolic sine (Column 1) or the logarithm (Column 2) of the number of new booster vaccinations within a week. Standard errors of the estimated coefficients are reported in parentheses. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Table 4: Heterogeneity Analysis (Booster shots), USA

	Asinh(New Boosters)	Asinh(New boosters)	Asinh(New boosters)
Direct	−0.058	−0.018	−0.020
	(0.081)	(0.052)	(0.242)
Friends	−0.030	0.005	−0.014
	(0.085)	(0.052)	(0.221)
Gossips	0.011	−0.029	−0.010
	(0.082)	(0.053)	(0.235)
Direct x GOP Win Margin	0.088		
	(0.179)		
Friends x GOP Win Margin	0.035		
	(0.190)		
Gossips x GOP Win Margin	−0.026		
	(0.187)		
Direct x Metro		−0.022	
		(0.091)	
Friends x Metro		−0.070	
		(0.096)	
Gossips x Metro		0.083	
		(0.091)	
Direct x % Complete at Baseline			0.000
			(0.005)
Friends x % Complete at Baseline			0.000
			(0.005)
Gossips x % Complete at Baseline			0.000
			(0.005)
GOP Win Margin	0.806	0.907	0.760
	(6.871)	(6.804)	(6.826)
% Complete at Baseline	−0.003	−0.002	−0.003
	(0.014)	(0.014)	(0.014)
Observations	9704	9704	9704
Week Fixed Effects	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Strata Fixed Effects	Yes	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of estimating three different regressions for the US to explore heterogeneity patterns by adding interactions with specific county-level characteristics. The number of new boosters in a week is used as outcome variable and only the "during" (26 Dec 2021 - 30 Jan 2022) and "post" (30 Jan 2022 - 20 Feb 2022) periods are used because no boosters were administered prior to the intervention. Column (1) presents a regression where treatment status is interacted with GOP Win margin in the 2016 elections. Column (2) includes the interaction with the status of the county of residence (mostly urban / mostly rural). Finally, Column (3) includes the interaction with the initial rate of completed vaccination schemes. All regressions include week, state and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Supplementary Table 5: Heterogeneity Analysis (Any new vaccine), USA

	Asinh(Any new vaccine)	Asinh(Any new vaccine)	Asinh(Any new vaccine)
Direct x during	−0.015	−0.037	−0.070
	(0.063)	(0.041)	(0.205)
Direct x post	0.079	−0.038	−0.019
	(0.079)	(0.061)	(0.224)
Friends x during	0.011	0.003	0.038
	(0.068)	(0.043)	(0.187)
Friends x post	0.107	−0.012	0.191
	(0.079)	(0.061)	(0.181)
Gossips x during	0.081	−0.063	−0.167
	(0.062)	(0.046)	(0.195)
Gossips x post	0.155*	−0.066	−0.154
	(0.086)	(0.064)	(0.224)
GOP Win Margin x Direct x during	0.008		
	(0.141)		
GOP Win Margin x Direct x post	−0.234		
	(0.151)		
GOP Win Margin x Friends x during	0.008		
	(0.156)		
GOP Win Margin x Friends x post	−0.230		
	(0.145)		
GOP Win Margin x Gossips x during	−0.232		
	(0.144)		
GOP Win Margin x Gossips x post	−0.439**		
	(0.174)		
is_urban x Direct x during		0.081	
		(0.075)	
is_urban x Direct x post		0.096	
		(0.095)	
is_urban x Friends x during		0.036	
		(0.077)	
is_urban x Friends x post		0.101	
		(0.097)	
is_urban x Gossips x during		0.151**	
		(0.071)	
is_urban x Gossips x post		0.147	
		(0.092)	
% Complete at Baseline x Direct x during			0.001
			(0.005)
% Complete at Baseline x Direct x post			0.000
			(0.005)
% Complete at Baseline x Friends x during			−0.001
			(0.004)
% Complete at Baseline x Friends x post			−0.004
			(0.004)
% Complete at Baseline x Gossips x during			0.004
			(0.004)
% Complete at Baseline x Gossips x post			0.003
			(0.005)
GOP Win Margin	3.143	3.050	2.925
	(6.414)	(6.390)	(6.396)
% Complete at Baseline	−0.077***	−0.076***	−0.077***
	(0.014)	(0.014)	(0.014)
Observations	21 834	21 834	21 834
Week Fixed Effects	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Strata Fixed Effects	Yes	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of the estimation of three different regressions for the US to explore heterogeneity patterns, by adding interactions with selected county-level characteristics. The number of any new vaccine dose is used as outcome variable. Column (1) presents a regression where the interaction with the 2016 election GOP Win-margin has been added. Column (2) includes the interaction with the status of the county of residence (urban or rural area). Finally, Column (3) includes the interaction with the initial rate of completed vaccination schemes. All regressions include week, state and strata fixed effects, as well as LASSO-selected controls from a pool of county-level demographics. Standard errors have been clustered at the county level.

Negative binomial regression for France
In France, we also carry out the analysis using a negative binomial regression because the distribution of new vaccinations per week is skewed towards zero.

$$Prob(Y = y_{it}|X_{it}) = \frac{\Gamma(\theta+y_{it})r_i^{\theta}(1-r_i)^{y_{it}}}{\Gamma(1+y_i)\Gamma(\theta)}$$

where $r_i = \theta/(\theta + \lambda_i)$ and $exp(\alpha + x_i'\beta + \varepsilon_i) = h_i\lambda_i$, where h_i is distributed $\Gamma(\theta, \theta)$. The negative binomial regression is estimated using the R MASS package and includes population, percentage of population with a first dose at baseline as well as week, region and strata fixed effects as control variables.

Supplementary Table 6a: Effects of Facebook campaigns on new COVID-19 dose 1 vaccinations (2 weeks aggregation), France

	Asinh(New Dose 1)	Log(New Dose 1 + 1)	New Dose 1 (negative binomial)
Direct x during	0.013	0.011	0.012
	(0.032)	(0.025)	(0.032)
Direct x post	−0.038	−0.034	−0.057
	(0.048)	(0.038)	(0.038)
Friends x during	0.005	0.006	0.016
	(0.033)	(0.026)	(0.032)
Friends x post	0.047	0.037	0.033
	(0.048)	(0.039)	(0.038)
Observations	13 981	13 981	13 981
Avg % with Dose 1 at Baseline	0.75	0.75	0.75
Week Fixed Effects	Yes	Yes	Yes
Strata Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table presents the result of the estimation of Equation (3) for France. Only the β_1, and β_2 coefficients are reported and show the effects of the campaigns on the inverse hyperbolic sine (Column 1) or the logarithm (Column 2) of the number of new first doses within two weeks. Finally, Column (3) presents the results of the negative binomial regression. Standard errors of the estimated coefficients are reported in parentheses. Regressions include week, region and strata fixed effects, as well as

LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the epci or postal code level.

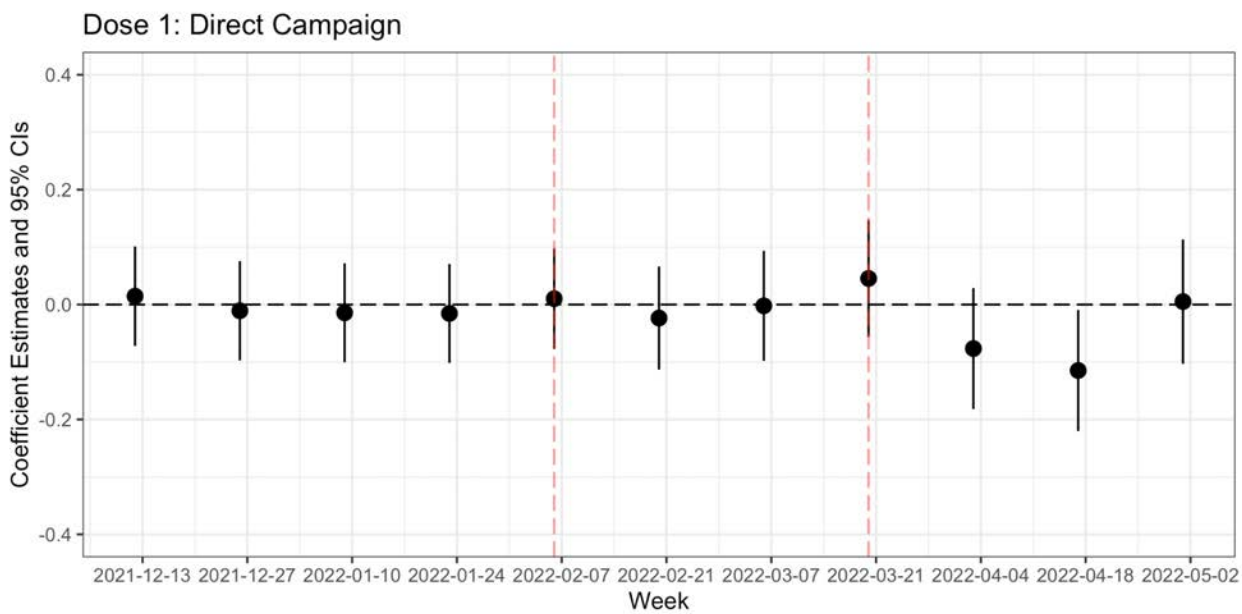
Supplementary Table 6b: Effects of Facebook campaigns on new COVID-19 dose 1 vaccinations (3 weeks aggregation), France

	Asinh(New Dose 1)	Log(New Dose 1 + 1)	New Dose 1 (Negative Binomial)
Direct x during	−0.008	−0.006	0.001
	(0.033)	(0.027)	(0.036)
Direct x post	−0.016	−0.014	−0.021
	(0.049)	(0.038)	(0.035)
Friends x during	−0.018	−0.010	0.018
	(0.035)	(0.029)	(0.036)
Friends x post	0.041	0.034	0.038
	(0.049)	(0.038)	(0.034)
Observations	10 168	10 168	10 168
Avg % with Dose 1 at Baseline	0.75	0.75	0.75
Week Fixed Effects	Yes	Yes	Yes
Strata Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

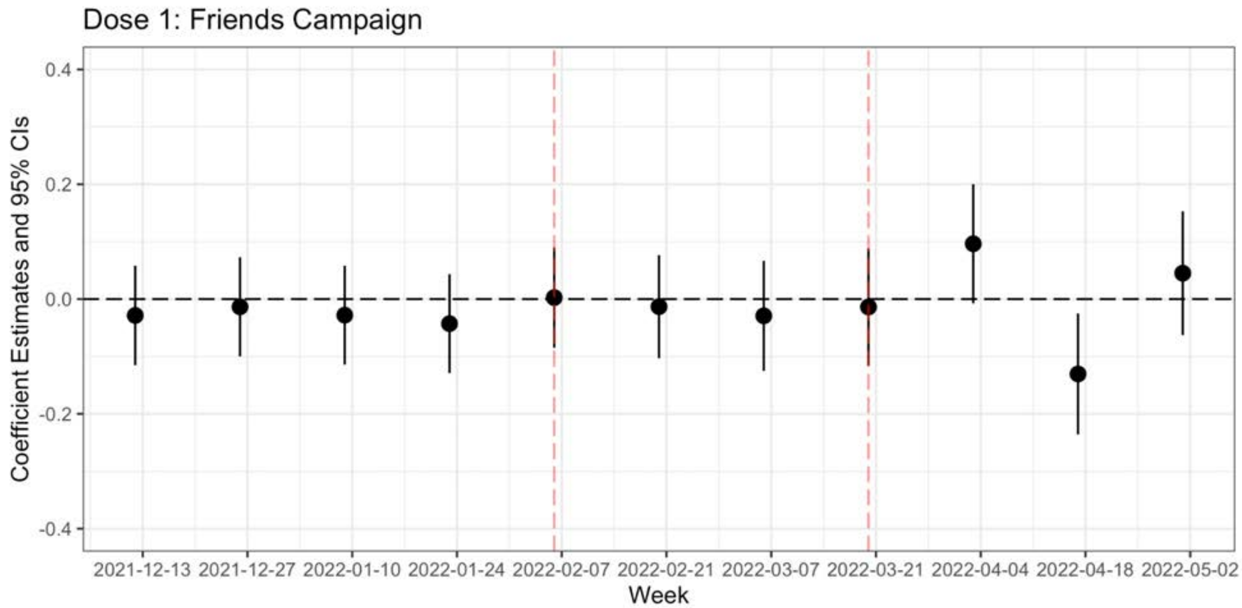
Note: This table presents the result of the estimation of Equation (3) for France. Only the β_1, and β_2 coefficients are reported and show the effects of the campaigns on the inverse hyperbolic sine (Column 1) or the logarithm (Column 2) of the number of new first doses within three weeks. Finally, Column (3) presents the results of the negative binomial regression. Standard errors of the estimated coefficients are reported in parentheses. Regressions include week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the epci or postal code level.

Supplementary Figure 7a: Two-week-by-two-week impact of the Direct campaign on first vaccination, France (negative binomial regression)



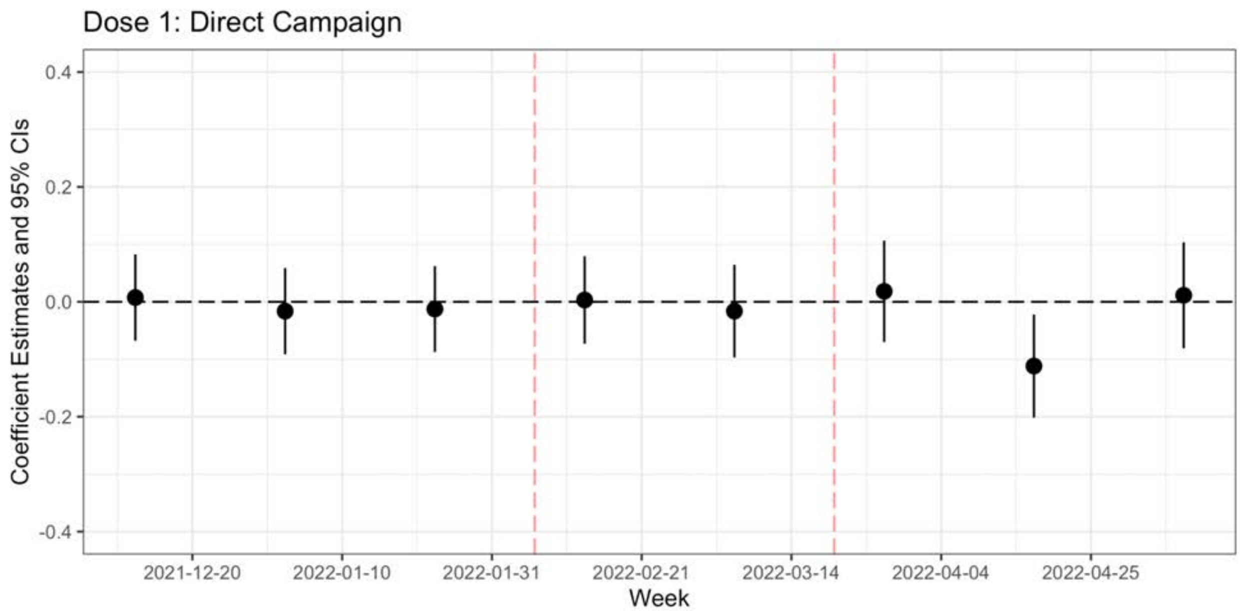
Notes: This figure presents the estimated coefficients $\beta_{1,t}$ with a negative binomial regression in Equation (2) for France along with 95% confidence intervals using the number of first dose vaccinations within two weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Figure 7b: Two-week-by-two-week impact of the Friends campaign on first vaccination, France (negative binomial regression)



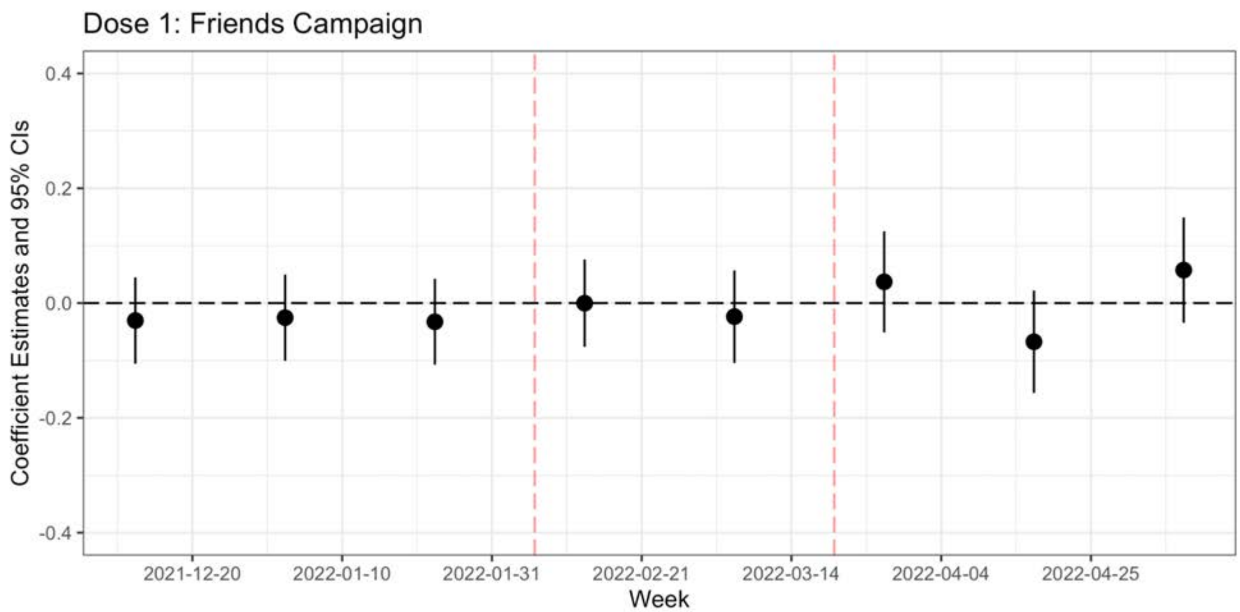
Notes: This figure presents the estimated coefficients $\beta_{2,t}$ with a negative binomial regression in Equation (2) for France along with 95% confidence intervals using the number of first dose vaccinations within two weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Figure 8a: Three-week-by-three-week impact of the Direct campaign on first vaccination, France (negative binomial regression)



Notes: This figure presents the estimated coefficients $\beta_{1,t}$ with a negative binomial regression in Equation (2) for France along with 95% confidence intervals using the number of first dose vaccinations within three weeks as the outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.

Supplementary Figure 8b: Three-week-by-three-week impact of the <u>Friends</u> campaign on first vaccination, France (negative binomial regression)



Notes: This figure presents the estimated coefficients $\beta_{2,t}$ with a negative binomial regression in Equation (2) for France along with 95% confidence intervals using the number of first dose vaccinations within three weeks as outcome variable. The red dotted vertical lines indicate the beginning and the end of the campaign. The regression includes week, region and strata fixed effects, as well as LASSO-selected controls including population and baseline vaccination rates. Standard errors have been clustered at the EPCI or postal code level.