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Make it easy: Lowering transaction costs substantially increases COVID-19 vaccination uptake

Frauke von Bieberstein, Anna-Corinna Kulle, Stefanie Schumacher *

Abstract

We examine the effect of reducing individuals' transaction costs for getting vaccinated against COVID-19 on vaccination decisions. In a field experiment, we sent mobile vaccination units to Swiss communities for half a day. We find an increase by the factor 3.4 (plus 9.0 percentage points) in the vaccination rate of the previously unvaccinated treatment group compared to the control group over a three-week period. The increase is present for all age groups and both genders. We find no evidence for cannibalization of vaccinations at other service locations. Thus, lowering transaction costs is highly effective in raising vaccination rates.

JEL classification: C93, D90, I12

Keywords: transaction costs; COVID-19; vaccination; field experiments

Declarations of interest: None

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1 Introduction

Vaccination is the decisive factor in overcoming the COVID-19 pandemic (Lavine et al., 2021; WHO, 2022). Yet despite the severe health and economic consequences of the pandemic, the vaccination curve in most high-income countries has flattened sharply since vaccines became widely available in the first half of 2021 (CDC, 2022; Federal Office of Public Health Switzerland, 2022; Lukpat, 2021). Moving from a supply problem to a demand problem, governments around the globe have started programs to increase vaccination rates. However, thus far, these programs have not been sufficient to achieve government vaccination targets.

When considering an individual’s decision to get vaccinated, the literature on vaccine uptake considers low transaction costs (i.e., the time needed to register before the vaccination appointment, the time to get the vaccination, and transportation costs)¹ among the most important factors (Betsch et al., 2018; Machingaidze and Wiysonge, 2021), but causal evidence for this claim is scarce.² The importance of keeping transaction costs low is also reflected in scientific advice for governments. For instance, Volpp et al. (2021) define five strategies, informed by insights from behavioral science, for the U.S. COVID-19 vaccine promotion program, with the first strategy being to make the vaccine free and easily accessible.

Research has proposed to compensate for transaction costs by paying people to get vaccinated. This has shown promising results (Campos-Mercade et al., 2021; Klüver et al., 2021; Serra-Garcia and Szech, 2021), and many governments have taken up the idea. To encourage vaccine uptake, they have paid moderate to high incentives (e.g., USD 25 in North Carolina (Wong et al., 2021), USD 100 in New York City (Oza, 2021), approximately USD 25 in Serbia (Holt, 2021), and approximately USD 180 in Greece (Reuters, 2021). However, this has also led to heated debates on whether paying people to get vaccinated is ethically justifiable (Persad and Emanuel, 2021; Savulescu et al., 2021) and on whether people who received the vaccination earlier should also receive the money retrospectively (Martel, 2021). In addition, there is a threat of crowding out intrinsic motivation for further vaccinations in the future (Loewenstein and Cryder, 2020).

Instead of compensation, in this paper, we consider the effect of a direct reduction of transaction costs, which can be considered less controversial. In particular, in a field experiment conducted in August 2021 ($N = 20,442$ unvaccinated adults), we examine the effect of sending a mobile vaccination unit to Swiss communities in the Canton of Solothurn for four hours on a single day. All adults in the treated communities received a letter highlighting the importance of vaccination and informing them about the visit of a mobile vaccination unit in their local community, where no appointments were needed. In the communities of the control group, adults received the letter but without the part about the mobile vaccination unit. Irrespective of the treatment, adults in all communities can

¹In all high-income countries, the vaccination itself is free of charge. Other transaction costs are, for instance, taking off time at work to get vaccinated and childcare costs while parents are being vaccinated.

²Global efforts, originally led by the WHO (2014), first identified three main individual-level determinants for vaccine hesitancy: Confidence, complacency, and convenience (or constraints). Recently, further factors were added: Risk calculation, collective responsibility (Betsch et al., 2018), conspiracy, and compliance (Geiger et al., 2021).

get vaccinated by making an appointment at a vaccination center or at their local doctors' offices and pharmacies.

We find that the vaccination rate of the previously unvaccinated in the treated communities is 9.0 percentage points higher than in the control communities (an increase by the factor 3.4) for our time span of three weeks. Notably, we see no evidence for cannibalization of vaccinations at dedicated vaccination centers or at local doctors' offices and pharmacies (3.9% vaccination rate of the previously unvaccinated in the treated communities and 3.7% in the control communities). Further analyses at the individual level of vaccination rates at vaccination centers and with the mobile team confirm the substantial effect of the intervention. The treatment effect is robust when controlling for age, gender, household size, and community vaccination rate. The increase is statistically significant for both age groups and both genders. Most notably, the effect size is also statistically significant for the age group 60 years and older, although the baseline vaccination rate in this group was 16–32 percentage points higher than in all other age groups (approximately 66% before the intervention). Not knowing how to otherwise get vaccinated does not drive the results, as people in both groups were informed about the website/hotline to make a vaccination appointment.

In a companion survey conducted at the same time as the experiment but in different Swiss communities ($N = 567$), we asked respondents to rate the attractiveness of different dimensions of the mobile offering. Based on the survey, mobile vaccination teams are attractive because of the possibility of showing up without an appointment, the close proximity, and the familiar environment in which they operate. We also find that the mobile vaccination offering is highly attractive for non-vaccinated individuals who are not fully opposed to the idea of being vaccinated in the future (54% of the non-vaccinated individuals in the survey sample).

Nearly all previous experiments on transaction costs for COVID-19 vaccinations have focused on offering financial incentives for the vaccination (e.g., Campos-Mercade et al. 2021; Dai et al. 2021; Klüver et al. 2021; Serra-Garcia and Szech 2021). As of early 2022, most of these experiments stem from the period when various age groups were first eligible to receive the COVID-19 vaccine, thus when demand significantly exceeded supply (Campos-Mercade et al., 2021; Dai et al., 2021). This first evidence shows that offering financial incentives positively affects vaccination rates, as shown in a randomized control trial in Sweden, where citizens were offered moderate amounts to get vaccinated (Campos-Mercade et al., 2021). In a survey experiment, Klüver et al. (2021) find evidence that moderate financial compensation (EUR 25 and EUR 50) increases intended vaccination uptake, with a doubling of the financial incentive leading to a more than doubling of the effect. Serra-Garcia and Szech (2021) show in an online experiment that monetary incentives can increase intention to get the COVID-19 vaccine. In a survey experiment, Klüver et al. (2021) also tested offering vaccinations at local doctors' offices as a way to decrease transaction costs. The authors find that this offering increases vaccination intention by 3 percentage points.

The present study makes several main contributions. First, we consider vaccination decisions when vaccines had been made widely available for several weeks, so that vaccination appointments were freely available for the general public the next day. At the time of the study, people thus had had

enough time to contemplate their vaccination decisions and to plan for a convenient vaccination date. Still, in this environment, we find a very large effect of the mobile vaccination unit being present for only four hours on a single day. Consequently, this study highlights the importance of keeping transaction costs as low as possible, even at a later stage, in vaccination campaigns. As in most of the communities there was also an opportunity to get vaccinated at a local doctor’s office or pharmacy, but with higher transaction costs (wait time, scheduling an appointment), proximity alone is likely not the only driver of the effect. Second, we find that the effect is also present for the high-risk group of people age 60 years and older, who had comparatively high vaccination rates before the intervention. Third, although many previous studies focus on vaccination intentions (Keppeler et al., 2021; Klüver et al., 2021; Pink et al., 2021; Serra-Garcia and Szech, 2021), we are able to observe actual vaccination behavior. Although intentions are an important antecedent of behavior, researchers have also shown that there is a gap between intentions and subsequent behavior, with intentions not always translating into actions (Ajzen, 1991; Ajzen and Czasch, 2009; Sheeran, 2002). Furthermore, the data allow us to control for important factors, such as the community vaccination rate. Finally, the intervention represents a very cost-effective way of increasing vaccination uptake. The mobile team uses rooms available in the community and thus requires only staff to administer the vaccine. Apart from that, there is transportation time and cost for the staff to get to the communities, and the cost to inform the public about the mobile offering.³

2 Experimental design

The ethical standards of the study were approved by the ethics committee of the University of Bern and the cantonal data protection office. The experimental details were pre-registered, and protection plans for sharing information between the involved communities and the canton of Solothurn were put in place.⁴

2.1 Situation in Switzerland / Solothurn

COVID-19 vaccinations started in Switzerland in December 2020 (Keystone, 2020) and after the elderly and people in risk groups had been vaccinated, the vaccine became available to the general population in mid-May 2021. In Switzerland, COVID-19 vaccinations are free of charge, and at the time of this study, either the Moderna or the Pfizer-BioNTech COVID-19 vaccine was administered. The field experiment was conducted in the German-speaking region of Switzerland, in the canton (i.e., state) of Solothurn⁵, in August 2021. In Switzerland, each canton is largely responsible for its

³In the experiment, the transportation time for the staff was always less than 1 hour from the capital of the canton of Solothurn to each community.

⁴The ethical standard was approved by the Faculty of Business Administration, Economics and Social Sciences of the University of Bern (July 14, 2021), serial number: 172021. The experimental details were pre-registered with the American Economic Association’s registry for randomized controlled trials with the unique identifying number AEARCTR-0008070.

⁵The canton of Solothurn has 273,504 inhabitants, corresponding to 3.2% of the Swiss population in 2020 (Federal Statistical Office of Switzerland, 2021)

own vaccination campaign, including the communication strategy and the implementation. At the onset of the study, more than 55.6% of people age 16 years and older in the 20 target communities had received at least one dose of a COVID-19 vaccine. However, although the initial demand for the vaccine was generally high in Switzerland, the vaccination rate began to stagnate from July 2021 onward, leading to many unused vaccination appointments. Before the experiment, inhabitants in the 20 communities had been vaccinated at dedicated vaccination centers and drive-ins (90.6% of vaccinations) and at local doctors' offices and pharmacies (9.4% of vaccinations). The canton had not used mobile vaccination teams before for the general public.⁶ For the field experiment, the mobile vaccination teams were set up on local premises that are normally used for community events. The offering lowered the transaction costs of getting vaccinated because people did not need an appointment and because travel time was reduced compared to vaccination centers.⁷ Additionally, vaccinations took place in a more familiar environment.

2.2 Sample selection and data set

The communities for this field experiment were selected based on their size. To ensure that a mobile vaccination team of five people would be able to vaccinate everyone who showed up for the offering, only communities with 1,500–3,500 inhabitants were eligible for the experiment. In total, 32 communities in the state of Solothurn fulfill this criterion. The field partner was able to offer 10 slots for mobile vaccination teams as part of the experiment. We randomly picked 20 communities and assigned them to either the treatment or control group, stratifying assignment based on the community size and the baseline vaccination rate available at the time.

All 45,991 residents age 16 years and older in the 20 communities received a personally addressed letter at their primary residence. Letters were sent to the entire population, including vaccinated individuals. We received fully anonymized data for all citizens age 16 years or older (and thus eligible for vaccination at the time of the study), including basic demographic information (age and gender) and household size. These individual-level data included information about COVID-19 vaccinations administered at vaccination centers before and during the study and at mobile vaccination units during the study. Data on vaccinations administered at local doctors' offices and pharmacies were available only at the community level.

2.3 Balancing checks

At the community level, we run balancing checks on pre-treatment vaccination rates at the different service locations, as well as for community size. In terms of size, the communities in the two groups

⁶Before this study was conducted, mobile vaccination teams were used only for on-site vaccinations in retirement homes and similar institutions.

⁷Average one-way travel to vaccination centers from the communities participating in this study was approximately 12 minutes by car and approximately 24 minutes with public transportation. The mobile vaccination teams reduced this travel time to 5–10 minutes walking distance (see Table S1 in the Appendix for the average commute times).

are well balanced and there is no significant difference ($p = 0.853$, Mann-Whitney rank sum test; ⁸ see Table S2 in the Appendix). For the vaccination rate, we had only approximate numbers before the experiment. The baseline vaccination rate is 53.6% in the control group and 57.6% in the treatment group, a statistically significant difference ($p < 0.001$, chi-square test). We control for community-level vaccination rates in the analysis. In addition, we show that our treatment effect holds for comparisons between communities with highly similar as well as with unequal pre-treatment vaccination rates (see Section 3.1).

At the individual level, excluding vaccinations administered at local doctors' offices and pharmacies, the control sample and the experimental sample show no statistically significant differences for gender and age groups. Household size (i.e., the number of adults age 16 years and older living in a shared household) is fairly evenly distributed, with, on average, 2.0 (control) and 2.1 (treatment) inhabitants per household.⁹ See Table S2 and Table S3 in the Appendix for all sample characteristics and balancing checks.

2.4 Control and treatment group interventions

Letters for both groups were framed as reminders to get vaccinated and provided a link to the appointment-scheduling website and the telephone number for appointments at vaccination centers (including drive-ins). At the time of the experiment, appointments were in high supply, and slots were generally available the following weekday. In the letter to the treatment group, a short note to the otherwise identical letter was added announcing that a mobile vaccination team would be visiting the local community soon. The canton sent mobile vaccination teams to each community for a four-hour time interval on one weekday. Letters arrived between Saturday, August 14, 2021, and Tuesday, August 17, 2021. The mobile vaccination teams visited the communities either on Thursday or Friday the same week (August 19 or 20) or on the following Monday (August 23). The date and the exact time of the visit of the mobile vaccination team to the respective community were included in the letter.

To install a sense of psychological ownership, all letters included a personal address. Further, the official seal of the canton was printed on the envelopes and the letters, and the letter was issued by the state's ministry of health to increase the likelihood of people opening the envelope, reading the letter, and trusting its content.

Additionally, two-thirds of the letters in the control group and two-thirds of the letters in the treatment group included one of two types of supplementary social norm information: People were informed in either relative or absolute numbers how many people in total and per age group had been vaccinated in Solothurn to install the descriptive social norm that vaccination is safe and has

⁸All statistical tests are two-sided.

⁹Children (up to age 15 years) are not included in the household size because they were not eligible to get vaccinated at the time of the study. The variable includes households with up to nine members.

been chosen by others similar to themselves. With this supplementary information, we controlled for social beliefs as a potential driver of vaccination uptake.

2.5 Intervention period and measurement

To measure the treatment effect, the period from Monday, August 16, 2021, to Monday, September 6, 2021, is considered. We include vaccinations as of August 16, as this is the first day when someone may have gotten vaccinated due to having read the reminder letter. We include vaccinations up to September 6, two weeks after a mobile vaccination team visited the last community, to account for the potential spillover or cannibalization effects of having had a mobile vaccination team in the community. This is also approximately three weeks after the reminder letters were delivered. It is unlikely that a one-time reminder would have an effect exceeding this period. We consider only first-time vaccinations. Second-dose appointments are automatically scheduled when the first appointment is made, and both vaccinations usually happen at the same location. Thus, during the study period, mobile vaccination teams administered only first-dose vaccinations (the team returned four weeks later to administer the second-dose vaccinations). The rate of individuals who received their first vaccination at a mobile team during the intervention period and later received their second dose is 94.1%, similar to the canton-wide average of 94.4% fully vaccinated, within the group of at least partially vaccinated (status January 4, 2022, Canton of Solothurn 2022).

3 Results

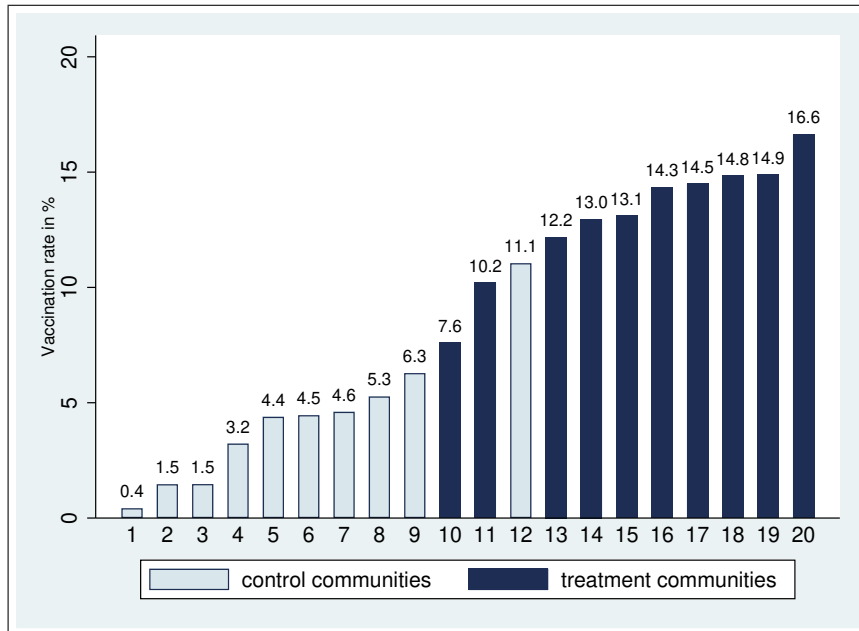
We split the analysis into two parts. In the first part, we consider the main treatment effect on the community level, which includes all vaccinations administered during the intervention period. In the second part, we make use of the rich individual-level data of vaccinations administered at vaccination centers and by mobile teams and analyze the effects of gender, age, household size, and community vaccination rate. This individual data set does not include vaccinations administered at local doctors' offices and pharmacies. However, with 87% of all vaccinations administered at the remaining service locations during the intervention period, it still represents by far the most of the vaccinations. In addition, as we show in Section 3.1, there is no statistically significant difference between the treatment and control groups regarding vaccinations at local doctors' offices and pharmacies during the intervention period.

3.1 Main treatment effect

In this section, we examine the influence of a mobile vaccination team on vaccination uptake. The sample consists of all adults in the 20 communities that had not received a COVID-19 vaccine before the intervention ($N = 20,442$). In the control treatment, in which residents received only a

reminder letter to make a vaccination appointment, 3.8% of this sample were vaccinated during the intervention period. In the treatment group, in which residents received the reminder letter and had a mobile vaccination team visit the community, the vaccination rate is 12.8%. The difference of 9.0 percentage points between the two groups is highly statistically significant ($p < 0.001$, chi-square test).¹⁰ As illustrated in Figure 1, the vaccination rate of the previously unvaccinated population is higher in all but one of the treated communities compared to the control communities.

FIGURE 1: Vaccination rates by community.



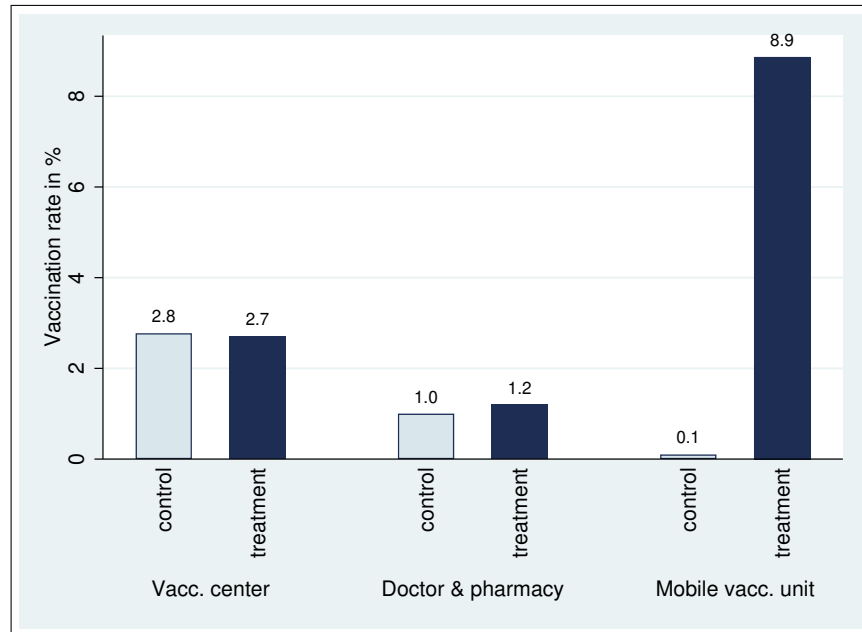
Given that the communities differ in their pre-treatment vaccination rates ranging from 47% to 69%, we compare the intervention period vaccination rate of each treated community with each control community (see Table S4 in the Appendix). Out of these 100 comparisons, the vaccination rate in the treated community is highly statistically significantly higher than in the control community, in all but seven cases. Thus, the effect of the mobile offering is present for comparisons between communities with very similar as well as with unequal pre-treatment vaccination rates.

Figure 2 shows that there is no evidence for cannibalization effects or spillover effects of the mobile offering on vaccinations at other service locations. There is no statistically significant difference in vaccination rates at vaccination centers between the treatment group and the control group (2.7% vs. 2.8%, $p = 0.783$, chi-square test). Similarly, there is no statistically significant difference in vaccination rates at local doctors' offices and pharmacies between the treatment group and

¹⁰When considering the entire population of all adults, including people who were vaccinated before the intervention, the vaccination rate increases by 1.8 percentage points in the control group and by 5.4 percentage points in the treatment group. The difference in vaccination rate increase is highly statistically significant ($p < 0.001$, chi-square test).

the control group (1.2% vs. 1.0%, $p = 0.116$, chi-square test). This shows that the difference in vaccination uptake is driven by the mobile offering.

FIGURE 2: Vaccination rates by treatment and service location.



3.2 The effect of individual-level characteristics

In this section, the sample consists of all adults in the 20 communities who had not received a COVID-19 vaccine at a vaccination center before the intervention ($N = 22,841$). The treatment effect is confirmed by the results of an ordinary least squares (OLS) regression analysis, as displayed in Table 1. As the treatment is administered at the community level, we cluster standard errors at this level (Abadie et al., 2017). We further correct for the small number of clusters (20 communities) following the approach of Porter and Serra (2020) by using wild cluster bootstrapping (Angrist and Pischke, 2008; Cameron and Miller, 2015). The dependent variable in all models is the vaccination decision, which takes a value of 1 if an individual has been vaccinated at a vaccination center or by the mobile team. All models show a highly statistically significant effect of the mobile vaccination treatment on vaccination uptake. The magnitude of the effect remains stable when controlling for gender (specification 2), age (specification 3), community baseline vaccination rate at the beginning of the intervention (specification 4), letter type (i.e., the inclusion of social norm information in the letter; specification 5), and household size (specification 6). When logistic regressions are run, the results also prove to be robust, with a stable effect size (see Table S5 in the Appendix).

The effect size of the treatment increases slightly, and the effect remains highly statistically significant when only the days the mobile vaccination teams were administering vaccinations in the treatment group are included (August 19–24, 2021). The same result occurs when the intervention period is

shortened to two weeks (August 16–30, 2021).¹¹ There is no significant difference between the two groups if only vaccinations administered at vaccination centers are considered (i.e., when vaccinations administered by the mobile vaccination team are excluded; see Table S7 in the Appendix).

A closer look at the people making use of the mobile vaccination offer reveals that the offering led to statistically significantly higher vaccination rates for both genders. The difference in vaccination rates compared to the control group is similar in magnitude and highly statistically significant for both genders, all three age groups, and all gender-age group combinations ($p < 0.001$, chi-square test; see Table S6 in the Appendix for details).¹² With regard to age, vaccination uptake is highest in the two younger age groups, but also substantial for the oldest age group, although that group had a pre-treatment vaccination rate of higher than 66% (including those inoculated at local doctors’ offices and pharmacies).

TABLE 1: Vaccination behavior during the study, specifications 1-6.

	Vaccinated (1)	Vaccinated (2)	Vaccinated (3)	Vaccinated (4)	Vaccinated (5)	Vaccinated (6)
Mobile-treat	0.075 (0.011)	0.075 (0.011)	0.075 (0.011)	0.071 (0.012)	0.071 (0.012)	0.068 (0.012)
Female		-0.007 (0.002)	-0.006 (0.002)	-0.006 (0.002)	-0.006 (0.002)	-0.005 (0.002)
Age			-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Community vacc rate				0.103 (0.089)	0.102 (0.089)	0.078 (0.098)
Letter type B					-0.003 (0.004)	-0.004 (0.005)
Letter type C					-0.001 (0.004)	-0.002 (0.004)
Household size						0.002 (0.003)
Constant	0.026 (0.006)	0.030 (0.006)	0.051 (0.010)	-0.003 (0.050)	-0.002 (0.051)	0.010 (0.054)
Boot- p mobile-treat	0.000	0.000	0.000	0.000	0.000	0.000
Observations	22,841	22,841	22,841	22,841	22,841	19,675

Notes: Robust standard errors clustered on the community level in parentheses. In specification 6, the number of observations drops because of missing household information. For two communities, only address-level information was provided, and households across all other communities that count 10 or more adults are also treated as missing, as they mostly are communal care facilities that are recorded as households by the authorities. The results are stable to including and excluding any number of adult household sizes. Letter type A refers to the control letter, letter type B to the letter type that includes a social norm using percentages, and letter type C includes a social norm using absolute numbers.

¹¹Period August 19–24, 2021 (only days with a mobile unit), coefficient 0.078, $p < 0.001$, boot $p < 0.001$ (OLS regression model); period August 16–30, 2021 (a two-week period instead of three-week period), coefficient 0.078, $p < 0.001$, boot $p < 0.001$ (OLS regression model).

¹²Three age groups are compared: Age group *Young* includes individuals age 16-39 years, age group *Adult* individuals age 40-59 years, and age group *Golden* individuals age 60 years and older.

3.3 Survey on the attractiveness of mobile vaccination teams

We conducted a companion survey at the same time as the experiment but in different Swiss communities ($N = 567$). Respondents were asked to rate the attractiveness of different dimensions of the mobile offering on a 7-point Likert scale (ranging from 1 = not at all attractive to 7 = highly attractive). The results show that mobile vaccination teams are attractive because of the possibility of stopping by without having made an appointment (mean 5.6, S.D. 1.9). Furthermore, shorter travel times compared to being vaccinated at a vaccination center were rated as being very attractive (mean 5.5, S.D. 1.9). In the field setting, the average one-way travel time to vaccination centers from the communities participating in this study was approximately 12 minutes by car and 24 minutes with public transportation. The mobile vaccination teams we sent to 10 communities reduced this travel time to a 5-10 minute walking distance (see Table S1 in the Appendix for the average commute times). This result emphasizes the importance of vaccination offerings in close proximity. In addition, vaccination in a familiar environment was rated positively (mean 5.0, S.D. 1.9). The mobile vaccination offering is highly attractive to vaccinated and currently non-vaccinated individuals who are not completely opposed to getting vaccinated against COVID-19 in the future. Of the 28.8% of individuals in the sample who have not yet been vaccinated, 54% consider potentially getting vaccinated in the future.¹³ This group also considers the mobile offering highly attractive because one can walk in without an appointment (mean 5.5, S.D. 1.6), travel times are shorter (mean 5.4, S.D. 1.7), and the environment is familiar (mean 5.1, S.D. 1.6).

4 Discussion and conclusion

Increasing vaccination rates is among the major challenges in the global COVID-19 pandemic. Lowering the transaction costs of being inoculated for individuals is an important way to address this challenge (Volpp et al., 2021). In this paper, we report the results of a field experiment that tested the effect of sending a mobile vaccination unit to Swiss communities for four hours on one day. Considering a time span of three weeks, we find a substantial increase of plus 9.0 percentage points in the vaccination rate of the previously unvaccinated population in the treatment group compared to the control group. We see no cannibalization or spillover effects of the treatment on other vaccination service locations (vaccination centers, local doctors' offices, and pharmacies).

The field experiment was conducted at a later stage of the vaccination campaign, when all individuals eligible for vaccination had had ample time to contemplate and discuss their own vaccination decisions. In addition, appointments at vaccination centers were in high supply, which kept transaction costs low because a convenient appointment date could be easily scheduled. Furthermore, in each community, a mobile vaccination unit was present for only four hours on a single day. The fact that we find such a substantial treatment effect in this type of environment highlights the importance of keeping

¹³Measured on a 7-point Likert scale ranging from 1 ("not at all") to 7 ("very likely") to get vaccinated in the future. All individuals who indicated a willingness higher than 1 are considered willing to potentially get vaccinated.

transaction costs as low as possible, even in a situation that seems a priori not very affected by this type of cost.

The treatment effect in the experiment is statistically significant and substantial in size among all age groups. This result is particularly interesting given that baseline vaccination rates before the intervention differed statistically significantly between age groups. Thus, the results give the first indication that bringing mobile vaccination units to communities appeals to individuals of all age groups who are, at a late point in the vaccination campaign, still unvaccinated.

There are several potential reasons why the mobile vaccination unit produced such a strong effect. In the survey, participants, most notably those who were not yet vaccinated but not strictly opposed to the idea, rated the possibility of getting vaccinated without an appointment, the proximity, and the familiar environment as very attractive. Although in most communities there was also the opportunity throughout the vaccination campaign to get vaccinated at a local doctor’s office or pharmacy, this offering prioritized previous clients, it required signing up online or calling the location to make the appointment, and the wait time to get an appointment varied greatly (from same-day to 30-day wait times). This shows that proximity alone is likely not the only reason for the strong effect of mobile vaccination teams, but the experiment cannot differentiate among the three likely reasons. Future research could investigate whether a single factor or a combination of these factors drives the effect.

The main reason for the attractiveness of the mobile vaccination offering may also differ between age groups, with proximity potentially being most important to the oldest age groups, as indicated by Klüver et al. (2021) and in line with our survey results. The mean ratings of the attractiveness (on a Likert scale ranging from 1 to 7) of the travel time reduction are, on average, 5.2 for the youngest age group, 5.6 for adults and 5.9 for the oldest age group.¹⁴ Moreover, the rating for requiring no appointment is highest for the oldest age group, with a mean of 5.8. For the young age group, it is 5.3, and for adults, it is 5.7. This potentially points out that appointment-free vaccination is a way not only to increase flexibility but also to reduce registration barriers for the elderly.¹⁵

Another reason for these results could be that having a specific “vaccination event” is driving the result. Although we cannot rule out this possibility, it seems less likely as no specific event characteristics were present: For instance, no food or beverages were offered, and people left the premises directly after the procedure. Further research could examine whether offering several visits by a mobile vaccination unit increases vaccination rates (due to even more flexibility) or decreases them (due to a less specific “event”). In addition, it would be interesting to investigate a combination of factors that influence transaction costs. In particular, mobile vaccination units could be combined with moderate payments for getting vaccinated to examine the interplay between these factors. The findings from this work can inform government vaccination strategies and provide a simple and

¹⁴Pairwise comparison according to two-sided Mann-Whitney rank-sum tests: *Young to Adult*, $p = 0.002$; *Young to Old*: $p < 0.001$; *Adult to Old*: $p = 0.035$.

¹⁵Pairwise comparison according to two-sided Mann-Whitney rank-sum tests: *Young to Adult*, $p = 0.007$; *Young to Old*: $p = 0.004$; *Adult to Old*: $p = 0.577$

cost-effective way to increase vaccination uptake in the still large group of unvaccinated individuals, as well as with respect to the need to administer booster vaccinations (third or additional dosages).

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Appendix: Supplementary tables

TABLE S1: Average travel times to closest vaccination center from local communities.

	Group	Average time by bus/train (in min)	Average time by car (in min)	Vaccinations available at local doctor	Vaccinations available at local pharmacy
Community 1	mobile-treat	19	11	yes	yes
Community 2	mobile-treat	22	17	yes	yes
Community 3	mobile-treat	20	10	yes	no
Community 4	mobile-treat	21	10	yes	no
Community 5	mobile-treat	42	28	yes	no
Community 6	mobile-treat	11	6	yes	no
Community 7	mobile-treat	23	13	yes	no
Community 8	mobile-treat	9	7	yes	no
Community 9	mobile-treat	23	11	yes	no
Community 10	mobile-treat	46	23	no	no
Community 11	control	37	20	yes	no
Community 12	control	30	12	yes	no
Community 13	control	13	9	yes	no
Community 14	control	31	16	yes	yes
Community 15	control	42	16	yes	no
Community 16	control	4	2	yes	yes
Community 17	control	18	9	yes	no
Community 18	control	14	8	yes	no
Community 19	control	22	9	no	no
Community 20	control	24	12	no	no

Notes: The table shows the average travel time to the closest vaccination center based on google maps calculations, not accounting for potential rush hour traffic or bus/train delays.

TABLE S2: Sample characteristics and balancing checks – all citizens aged 16 years or older of the 20 communities.

		Full sample n=45,991	Control n=23,548	Mobile-treat n=22'443	<i>p</i> -value
Communities	n=	20	10	10	
Community size	mean	2,299.6	2,354.8	2'244.3	0.853
	(S.D.)	(741.7)	(774.9)	(744.5)	
Vaccination rate	in %	55.6	53.6	57.6	<0.001
Female	in %	50.3	50.4	50.2	0.674
Age	mean	50.1	50.2	49.9	0.101
	(S.D.)	(18.8)	(19.0)	(18.7)	
16-39	in %	32.7	32.8	32.6	0.683
40-59	in %	34.1	33.6	34.6	0.030
60+	in %	33.2	33.6	32.8	0.075
Household-size	mean	1.9	1.9	1.9	<0.001
	(S.D.)	(0.9)	(1.0)	(0.9)	

Notes: The table shows the distribution of community size and community vaccination rate at the beginning of the intervention at the community level. On the individual level, the table shows the distribution of gender, age, age groups, and household size for the whole sample and for the control and mobile vaccination communities. Household-size respects households with up to nine members aged 16 years and older. The last column reports the *p*-value from a Mann-Whitney rank sum test for community size and the *p*-value from a chi-square test for vaccination rate. For the other variables, the last column reports *p*-values of F-tests from regressions of the respective characteristics on individual treatment dummies.

TABLE S3: Sample characteristics and balancing checks. Unvaccinated and local doctor/pharmacy vaccinated population at the start of the intervention.

		Full sample n=22,841	Control n=11,908	Mobile-treat n=10,933	<i>p</i> -value
Communities	n=	20	10	10	
Female	in %	50.7	51.2	50.3	0.193
Age	mean	45.1	45.2	45.00	0.459
	(S.D.)	(17.8)	(17.9)	(17.8)	
16-39	in %	42.9	42.9	42.9	0.983
40-59	in %	34.6	34.4	34.7	0.688
60+	in %	22.5	22.7	22.4	0.665
Household-size	mean	2.0	2.0	2.1	0.008
	(S.D.)	(1.1)	(1.1)	(1.0)	

Notes: The table shows the distribution of gender, age groups, and household-size for the whole sample and for the control and mobile vaccination communities. The last column reports *p*-values of F-tests from regressions of the respective characteristics on individual treatment dummies.

TABLE S4: Pair-wise comparisons of vaccination rates between treatment and control communities (unvaccinated sample) during the intervention period.

		Treatment communities									
<i>Community</i>		1	2	3	4	5	6	7	8	9	10
<i>Vacc rate base</i>		48.9	49.4	52.4	58.3	58.9	59.0	61.2	61.3	62.6	69.4
<i>Vacc rate treat</i>		[7.6]	[12.2]	[16.6]	[14.3]	[14.9]	[14.8]	[10.2]	[14.5]	[13.0]	[13.1]
Control communities	1 46.8 [1.5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	2 48.7 [3.2]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	3 49.8 [4.5]	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	4 50.3 [1.5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	5 51.2 [0.4]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	6 54.2 [4.6]	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	7 55.7 [4.4]	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	8 57.6 [5.3]	0.069	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	9 64.2 [11.1]	0.050	0.059	<0.001	0.001	<0.001	0.001	0.837	0.002	0.051	0.064
	10 64.2 [6.3]	0.340	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	<0.001

Notes: The table reports p -values from chi-square tests. Each test compares the vaccination rate (*vacc rate treat*) of the previously unvaccinated from a given control to a treatment community. *Vacc rate base* reports the vaccination rate of the full population prior to our intervention period.

TABLE S5: Vaccination behavior during the study, log specifications 1-6.

	Vaccinated (1)	Vaccinated (2)	Vaccinated (3)	Vaccinated (4)	Vaccinated (5)	Vaccinated (6)
Mobile-treat	1.434 (0.248)	1.433 (0.248)	1.433 (0.246)	1.363 (0.238)	1.362 (0.238)	1.239 (0.212)
Female		-0.126 (0.040)	-0.116 (0.039)	-0.119 (0.038)	-0.119 (0.038)	-0.091 (0.036)
Age			-0.009 (0.003)	-0.009 (0.003)	-0.009 (0.003)	-0.008 (0.003)
Community vacc rate				1.849 (1.695)	1.846 (1.699)	1.288 (1.651)
Letter type B					-0.043 (0.078)	-0.060 (0.077)
Letter type C					-0.013 (0.074)	-0.038 (0.071)
Household size						0.027 (0.044)
Constant	-3.622 (0.223)	-3.559 (0.220)	-3.182 (0.256)	-4.156 (0.948)	-4.136 (0.952)	-3.808 (0.907)
Boot- <i>p</i> mobile-treat	0.000	0.000	0.000	0.000	0.000	0.000
Observations	22,841	22,841	22,841	22,841	22,841	19,675

Notes: Robust standard errors clustered on the community level in parentheses. In specification 6, the number of observations drops because of missing household information. For two communities, only address-level information was provided, and households across all other communities that count 10 or more adults are also treated as missing, as they mostly are communal care facilities that are recorded as households by the authorities. The results are stable to including and excluding any number of adult household sizes. Letter type A refers to the control letter, letter type B to the letter type that includes a social norm using percentages, and letter type C includes a social norm using absolute numbers.

TABLE S6: Vaccination rates by treatment group, age, and gender during the intervention period.

	All (1) n=22,841	Control (2) n=11,908	Mobile-treat (3) n=10,933	<i>p</i> -value (2) vs. (3)	
Female					
All	(n=11,589)	5.8	2.4	9.5	<0.001
Young	(n=4,870)	6.6	2.9	10.5	<0.001
Adult	(n=3,952)	6.3	2.7	10.4	<0.001
Golden	(n=2,767)	3.8	1.4	6.5	<0.001
Male					
All	(n=11,252)	6.6	2.8	10.6	<0.001
Young	(n=4,932)	6.5	2.8	10.5	<0.001
Adult	(n=3,940)	7.2	3.0	11.7	<0.001
Golden	(n=2,380)	5.7	2.4	9.2	<0.001

Notes: The table shows the vaccination rates within the group of unvaccinated individuals by gender and age groups, for the whole sample and for the two conditions. The table reports *p*-values from two-sided chi-square tests. Age group *Young* includes individuals age 16-39 years, age group *Adult* individuals age 40-59 years, and age group *Golden* individuals age 60 years and older.

TABLE S7: Vaccination behavior during the study, excluding mobile team vaccination, specifications 1-6.

	Vaccinated (1)	Vaccinated (2)	Vaccinated (3)	Vaccinated (4)	Vaccinated (5)	Vaccinated (6)
Mobile-treat	0.000 (0.006)	0.000 (0.006)	0.000 (0.006)	-0.005 (0.005)	-0.005 (0.005)	-0.006 (0.005)
Female		-0.002 (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.002 (0.002)	-0.001 (0.002)
Age			-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Community vacc rate				0.121 (0.037)	0.120 (0.037)	0.106 (0.039)
Letter type B					-0.004 (0.003)	-0.004 (0.004)
Letter type C					0.000 (0.002)	0.000 (0.002)
Household size						0.001 (0.002)
Constant	0.025 (0.006)	0.027 (0.006)	0.042 (0.007)	-0.022 (0.023)	-0.020 (0.024)	-0.013 (0.023)
Boot- <i>p</i> mobile-treat	0.990	0.986	0.993	0.421	0.419	0.253
Observations	21,990	21,990	21,990	21,990	21,990	18,902

Notes: Robust standard errors clustered on the community level in parentheses. In specification 6, the number of observations drops because of missing household information. For two communities, only address-level information was provided, and households across all other communities that count 10 or more adults are also treated as missing, as they mostly are communal care facilities that are recorded as households by the authorities. The results are stable to including and excluding any number of adult household sizes. Letter type A refers to the control letter, letter type B to the letter type that includes a social norm using percentages, and letter type C includes a social norm using absolute numbers. The bootstrapped *p*-values are averaged across five runs to increase stability. Individual runs show variances of up to 0.05, not affecting the non-significance of the results.